Field Procedures Manual – Appendices (2012 Edition)

Manual

Jeffrey Ferguson
2012.04.24
14:22:35 -04'00'

Manager / Process Owner Approval

Revision History

Date	Revision Description (Reason/What)	Updated by
04/24/2012	2012 Edition released	Paul Turner

(Latest change at the top of the table)

CONTENTS

*Note: This XML file can be downloaded from the Appendices by selecting the Attachments pane, right-clicking on the file name, and selecting “Save Attachment.”

Appendix 1

Systems Preparation & Maintenance

CONTENTS

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

(to be dated when signed)

MEMORANDUM FOR: Jeff Ferguson
Chief, Hydrographic Surveys Division or

Howard Danley
Chief, Navigation Services Division

FROM: LCDR Joseph Hydrohead, NOAA
Commanding Officer, NOAA Ship SWATH

SUBJECT: NOAA Ship SWATH Hydrographic Systems Status Summary

The hydrographic systems of NOAA Ship SWATH were reviewed in accordance with the Office of Coast Survey Field Procedures Manual (FPM) Hydrographic Systems Readiness Review procedures on January 28, 2010. The review process took place at NOAA's Marine Operations Center in Norfolk, Virginia, and was conducted by a Hydrographic Systems Review Team comprised of the following people:
Lieutenant Jane Doe, HSTP Field Support Liaison
Lieutenant Ida Know, Field Operations Officer, NOAA Ship SWATH
Mr. Thomas Smith, Physical Scientist, AHB

The Review Team's findings are summarized in this memorandum and reflect the condition of the SWATH field unit's hydrographic systems on the review date. These findings have been divided into three categories of deficiencies:

CATEGORY 1 – These deficiencies indicate the failure or absence of vital equipment or preparations of systems essential to acquisition and/or processing of hydrographic data. The vessel will be required to cease or limit hydrographic survey operations due to the following deficiencies:

1. The hull of launch number 2901 has structurally cracked and the vessel has been removed from service until repairs are made. This vessel should not be used for hydrographic survey operations until the crack has been repaired.

2. The ship's multibeam echosounder (MBES) was replaced during the current dockside repair period. A calibration (patch test) has not yet been conducted for this system due to ongoing ship repairs. The ship's MBES system can not be used to acquire data for NOAA hydrographic surveys until a successful system calibration has been performed.

3. Side scan sonar (SSS) towfish S/N 8675309 failed to detect the 1 m^3 test object nine out of ten times during calibration. No evidence of damage was noted on the towfish. After three unsuccessful attempts to complete the SSS calibration, EED was contacted and the towfish

Comment [J1]: This memo is to be submitted as a digitally signed PDF document. Email a copy of this memo to OCS.HSRR@noaa.gov returned to the manufacturer for evaluation and any necessary repairs. Towfish repairs had not been completed at the time of this review.

CATEGORY 2 – These deficiencies indicate noncompliance with established policies, directives, instructions, or accepted hydrographic practice not addressed under Category 1. The following deficiencies shall be corrected in as timely a manner as funding, time, and/or professional assistance permit:

1. The field unit's Diver Least Depth Gauge (DLDG) is overdue for calibration. This system must be calibrated by the manufacturer annually.

2. The side scan cable counter on Launch 2902 is broken, and the cable has been manually marked. These markings are deteriorating and no longer considered accurate. An accurate method of measuring cable out is required for side scan operations.

3. To analyze a horizontal control reference station, a second portable DGPS reference station is needed for comparison. SWATH is not equipped to set up a second portable DGPS reference station due to loss of equipment during the 2004 field season.

4. The field unit is currently performing GIS functions using MapInfo version 6.5. While this software version will perform locally without problems, OCS has upgraded to version 8.0. Project files and workspaces created using MapInfo version 8.0 may not be compatible with version 6.5.

CATEGORY 3 – These deficiencies are associated with observations during the course of the review which merit consideration for corrective actions. These observations are included for review and dialogue related to potential problem areas and hydrographic operational efficiency. It is important to assure that resources (funds, skills, and time) are available at the operating level in order to meet the needs identified in this report and to sustain the efficient operation, upkeep, and repair of the field unit's hydrographic systems.

1. Offset measurement and dynamic draft measurements for SWATH have not been completed for 2006. The ship intends to operate for the 2006 field season using historical values determined when the ship's Elac 1050D MBES was installed. Based in the inherent inaccuracy of the Elac system and the more relaxed requirements of IHO S-44 Order 2 surveying for which it is employed, the field unit considers historical offset and dynamic draft values to be adequate.

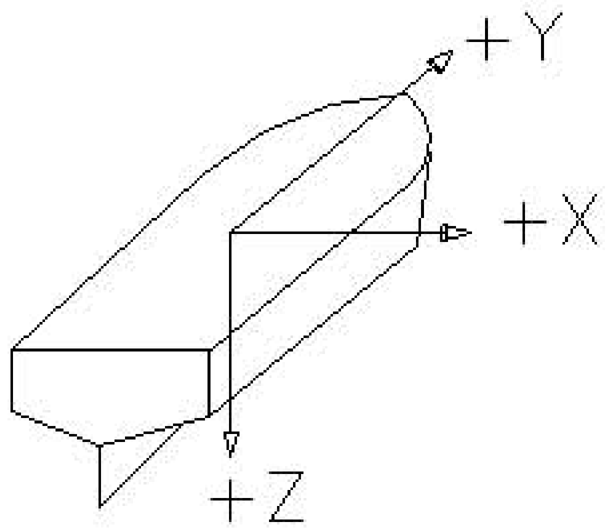
2. Launch 2901 is equipped with a POS/MV version 3 system. The review team recommends that this system be upgraded to a version 4 system so that Precise Timing methods can be implemented with the launch's Reson 8125 MBES system.

DATA STORAGE AVAILABILITY

Platform	Free Space (TB)	Used Space (TB)

Coordinate Systems for Common OCS Equipment & Software

CARIS COORDINATE SYSTEM

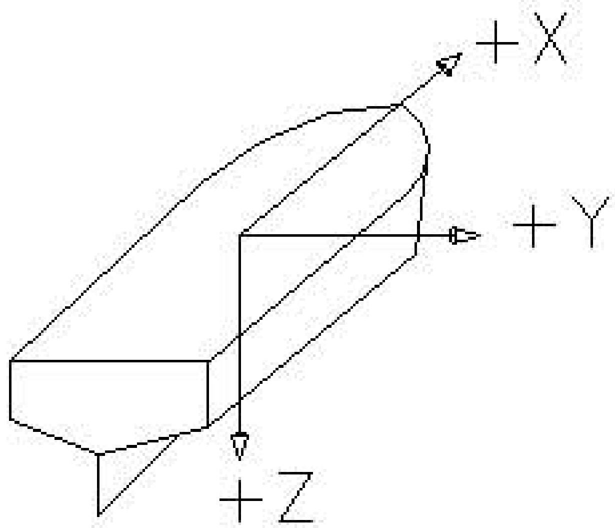


RFERENCE DATUM: WATERLINE
ORIGIN: RP defined in vessel reference frame
Note: Left handed coordinate system.

The Caris coordinate system is used when entering offsets in the Vessel Configuration Editor. For sidescan, these offsets are applied to ship nav to get a fish position when Recomputing SSS Nav.

For multibeam, the offsets are nessecary to reference the MBES head to the IMU.

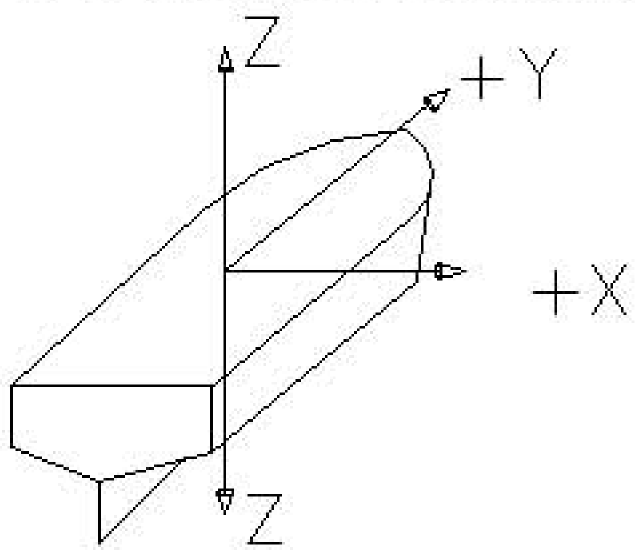
POS/MV COORDINATE SYSTEM



RFERENCE DATUM: TOP OF IMU
ORIGIN: Cross-hair on top of IMU
Note: Right handed coordinate system.

POS/MV coordinate system is used to locate the GPS antennae and multibeam to the IMU for ship navigation and MB attitude. These offsets are entered in the POS/MV controller program on initial setup.

HYPACK COORDINATE SYSTEM



RFERENCE DATUM: WATERLINE
ORIGIN: Survey transducer phase-center

Note: For most siutations, the "Y" offset is positive towards the bow, except in the case of the cable–counter layback where "Y" is positive to the stern. For the vertical offsets, the value entered will most often be positive, no matter what the direction, ie. antenna height is (+) and transducer depth in (+).

POS/MV Calibration Report

Field Unit:

SYSTEM INFORMATION

Vessel: ______

Date: ______ **Dn:** ______

Personnel: ______

PCS Serial # 786

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.10d

POS Version (Use Menu View > Statistics) MV320 Ver3

GPS Receivers

Primary Receiver SGN 99330009

Secondary Receiver SGN 98370085

CALIBRATION AREA

Location: Ketchikan, AK

Approximate Position:

	D	M	S
Lat	55	19	46
Lon	131	37	27

DGPS Beacon Station: Annette Island, AK

Frequency: 323 kHZ

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

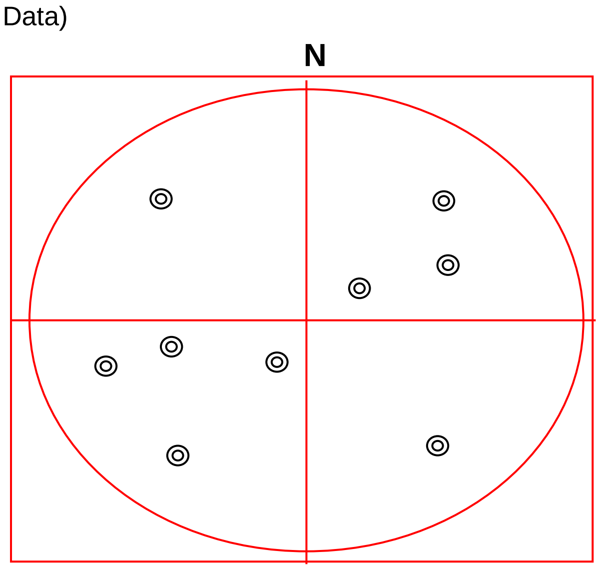
HDOP: 0.873

VDOP: 1.033

Sattelites in Use: 9

1,4,11,13,16,20,23,25,30

PDOP 1.352 (Use View> GAMS Solution)



Note: Secondary GPS satellite constellation and number of satellites were exactly the same as the Primary GPS

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.834	Two Antenna Separation (m)
0.30	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0	X Component (m)
0	YComponent (m)
0	Z Component (m)

Configuration Notes: GAMS needed re-calibration because the leverarm for IMU to Port Antenna was incorrect

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 10:18 UTC

End time: 10:20 UTC

Heading accuracy achieved for calibration: 0.099

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values

1.831	Two Antenna Separation (m)
0.300	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.002	X Component (m)
1.831	YComponent (m)
0.021	Z Component (m)

GAMS Status Online? X

Save Settings? X

Calibration Notes: Took over an hour to get fixed OTF solution and GAMS Ready Offline

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: POSMV_09012004.nvm

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

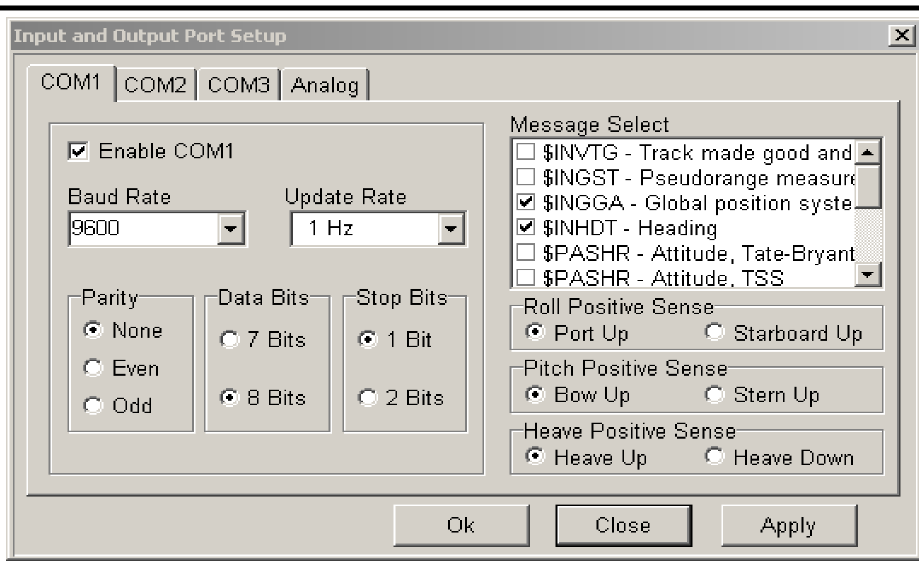
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

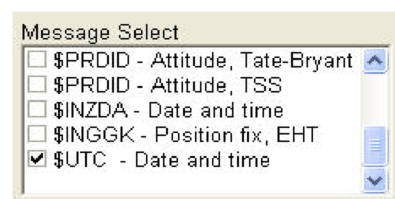
b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

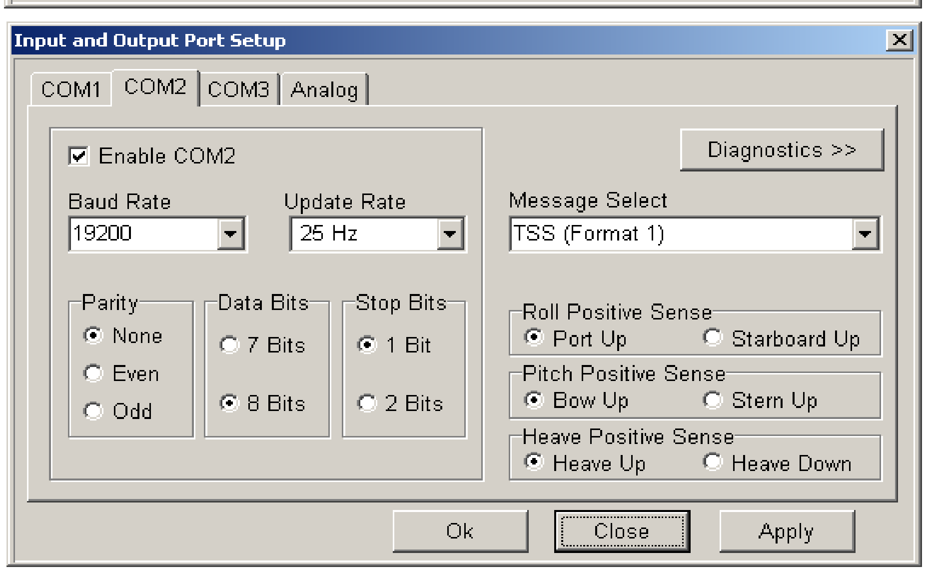
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)

Input/Output Ports (Use Settings > Input/Output Ports)

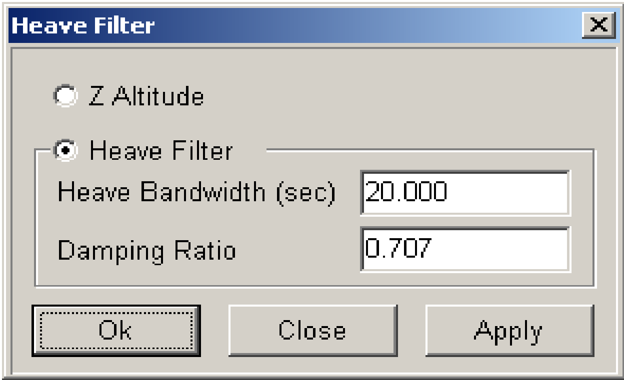




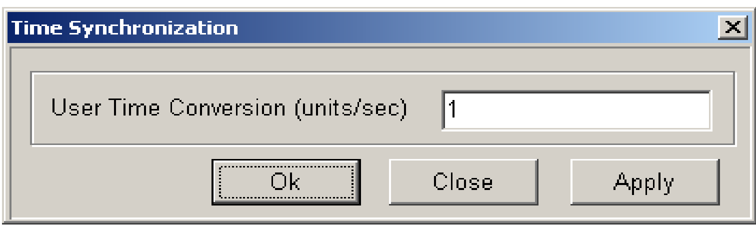


NOTE: COM3 and Analog are not used.

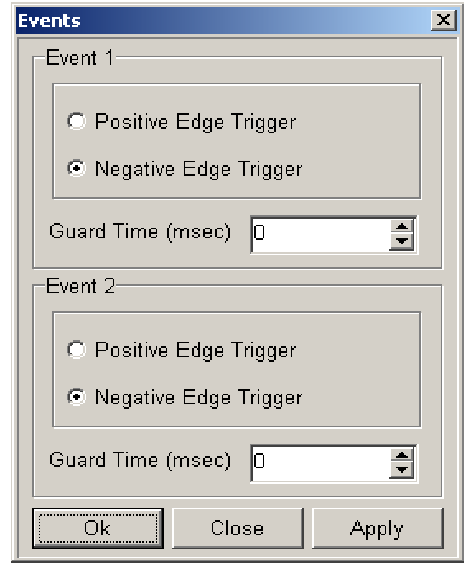
Heave Filter (Use Settings > Heave)



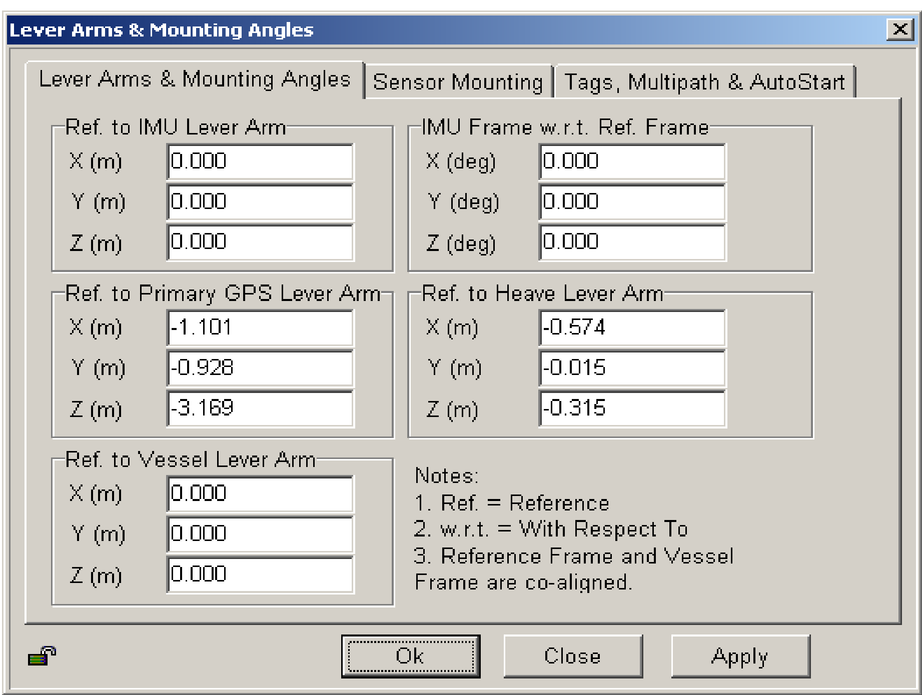
Time Sync (Use Settings > Time Sync)



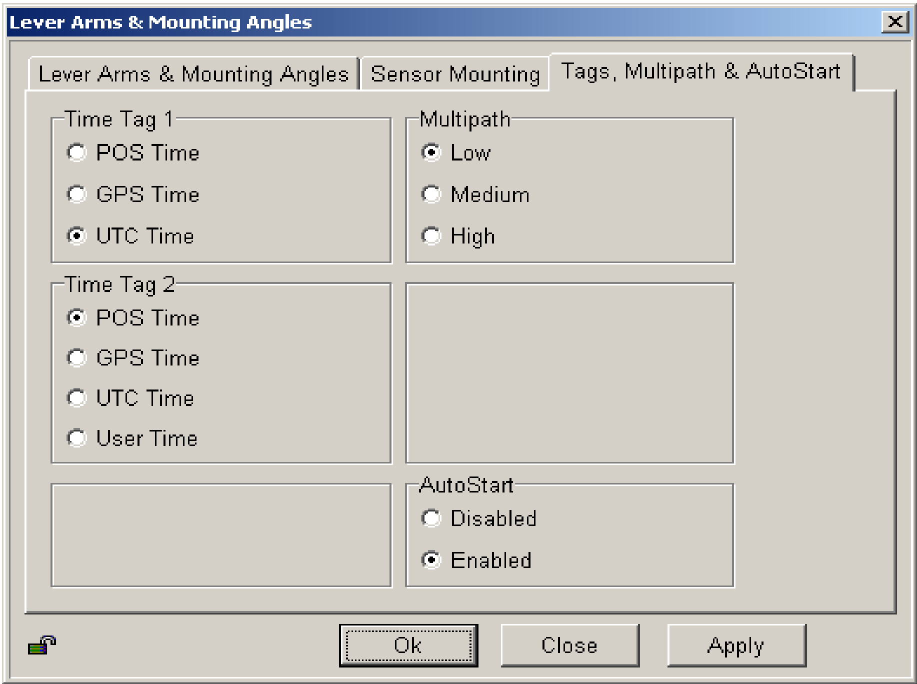
Events (Use Settings > Events)



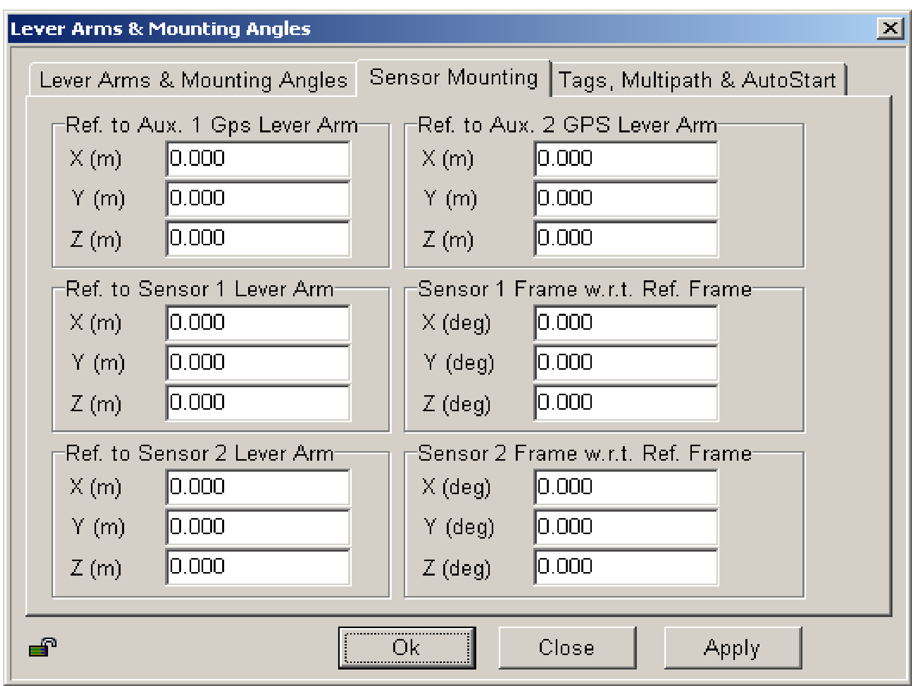
Installation (Use Settings > Installation)



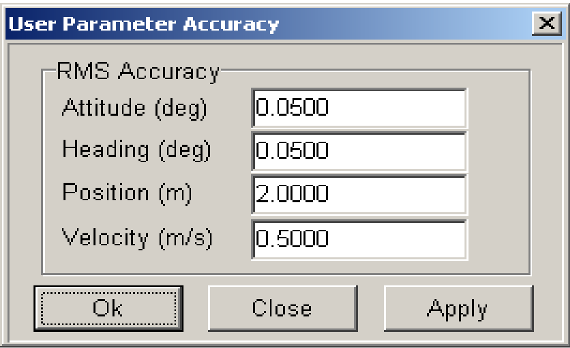
Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



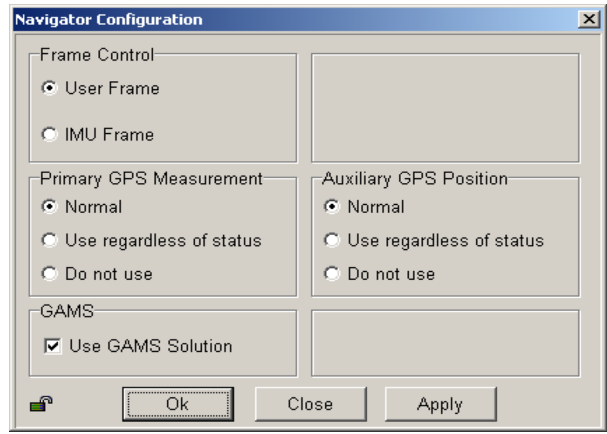
Sensor Mounting (Use Settings > Installation > Sensor Mounting)



User Parameter Accuracy (Use Settings > Installation > User Accuracy)

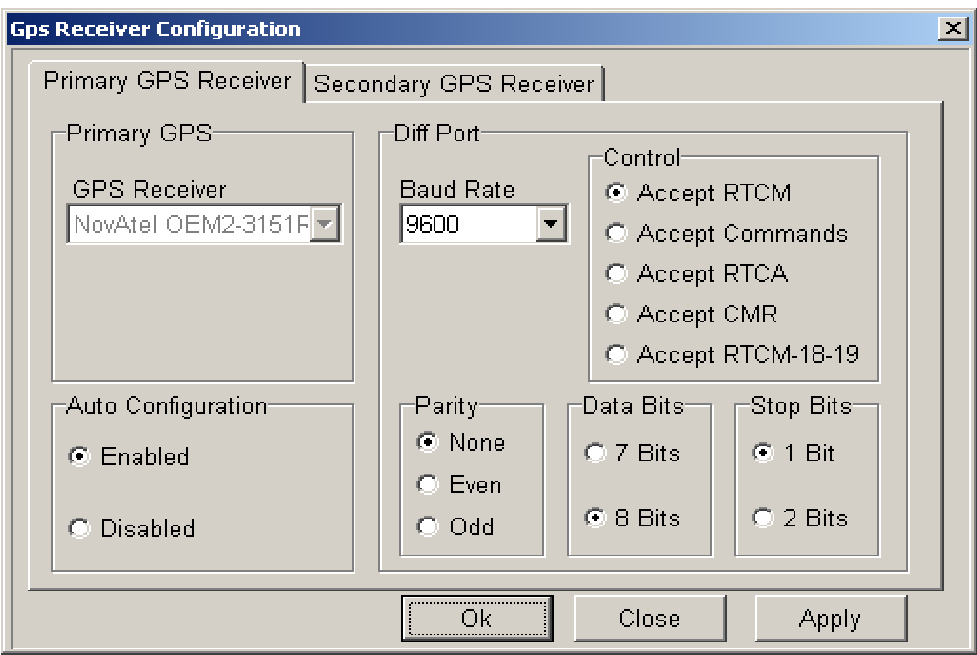


Frame Control (Use Tools > Config)

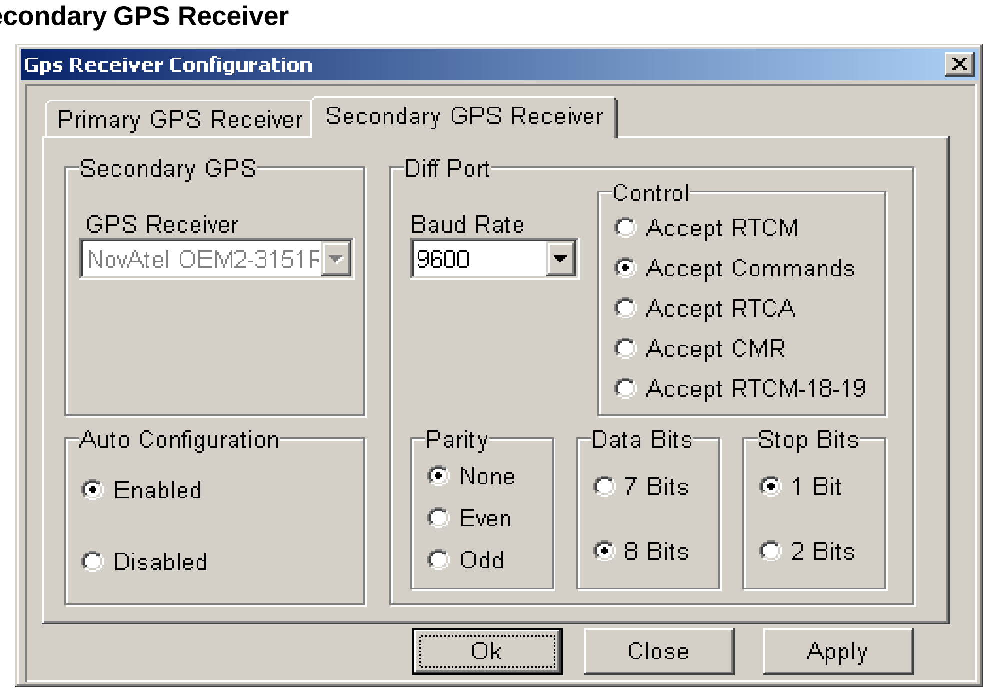


GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Secondary GPS Receiver



DIRECTIONS FOR CREATING TRADITIONAL LEAD LINES AND SOUNDING POLES

(excerpted from the *NOAA Hydrographic Manual*, July 1976, with modifications)

Traditional Lead Line Construction

I. Material

Standard lead line material is mahogany-colored tiller rope with a phosphor-bronze wire center. The center consists of six strands of seven 33-B (S-gage) wires each. The wire core is flexible and should not break after continual use and coiling. The rope is size 8 (about 0.24 in. in diameter), and is made of waterproofed, solid braided, long-staple cotton. The braid should be tight enough so that broken wire strands will not protrude through the covering and injure a leadsman's hands. Material for lead lines may either be requisitioned from the Marine Centers or be purchased from a well-equipped marine supply dealer.

II. Fabrication and Marking

Depending on the depths in which they will be used and on the size of the vessel, lead lines should be 30 to 60 meters long. Each lead line is identified by a consecutive number stamped on a metal disk attached at the inboard end of the line. Identification is made when a line is initially graduated. This number is to be retained throughout the life of the lead line or until re-marking is necessary. The braided covering of an unseasoned lead line tends to shrink when wet causing the wire core to buckle and the strands to break. Broken strands are likely to protrude through the covering and cause hand injuries. To prevent rupturing the core with repeated use, pre-season each lead line as follows:

1. Prepare the lead line by soaking it in salt water for 24 hours. Then, while the line is still wet, work the cotton covering along the wire by hand until the wire protrudes from the covering. The wire should protrude about 1/3 meter for each 20 meters of line. This is a tedious procedure requiring the cooperative efforts of several people. The covering can be pushed back and slackened only a few inches at a time; this length of slack must be pushed nearly the full length of the line before the next small section can be started. The excess protruding wire is cut off. The covering must not be worked back too far, or it will form bulges along the wire. Lead lines so prepared will maintain an almost constant length for future use.

2. Next, the line is dried under tension (about 50 lb) and then soaked again for 24 hr. Never boil a lead line as this destroys the waterproofing of the cover.

3. After attaching a lead to the line, the line should be wetted down again and placed under a tension equal to the weight of the lead; this tension is maintained while the line is being graduated. Temporary marks made at this time can be used for later permanent marking. Graduation marks on a new lead line may be laid off with a steel tape. The best method, however, is to mark the distances permanently on a suitable surface such as on the deck of a ship or on a wharf if the survey party is shore based. Permanent markings are convenient when verifying the graduations in the future. Lead lines for NOAA hydrographic surveys should be graduated in meters, with intermediate marks to permit readings to the nearest decimeter. Each meter should be marked by a seizing of black thread, with a leather strip clearly indicating the numerical value for even meter intervals. Each even decimeter (0.2,

0.4, 0.6, and 0.8) is marked by a seizing of white thread. Odd tenth readings are estimated. Waxed linen thread should be used to secure marks to the lead line in such a manner that there can be no possibility of slippage. Do not insert the thread through the braided covering of the line.

III. Verification

When checks of traditional lead lines are made, the lead lines must be wet and under a tension equal to the weight of the attached lead in water. The testing standard should be a good recently calibrated steel tape or pre-measured graduation marks on deck or ashore. Replace or re-mark lead lines if the errors exceed 0.1 meter.

IV. Sounding Leads

Each survey unit should have one or more leads. Leads come in standard weights of 5, 7, 9, 14, and 25 lb are requisitioned from the Marine Centers. Various methods may be used to attach the lead to the lead line. The preferred method is to have a galvanized thimble at the lower end of the lead line to which the lead can be attached by a shackle.

Traditional Sounding Pole Construction

I. Material

A sounding pole is made from a 5 meter length of 1.5 inch (3.81 cm) round lumber capped with a weighted metal shoe at each end to hasten sinking. Shorter poles may be used depending on the depth conditions.

II. Fabrication and Marking

Any convenient system of marking that is symmetrical toward both ends and will minimize reading errors may be used. The following marking system is recommended:

Mark each meter and even decimeter graduation (0.2, 0.4, 0.6, and 0.8) permanently by cutting a small notch in the pole. Paint the entire pole white; then paint odd decimeter graduation marks black.

III. Verification

Sounding poles must be verified against a known standard, such as a survey quality metal tape, to ensure that depth markings are unambiguous and accurate.

Lead Line & Sounding Pole Calibration Report

Field unit:

Lead Line / Sounding Pole Identification Number:
(Unique Identifier, with equipment type, date made, etc.)

Date of Calibration:

Method of Calibration: ☐
Other

Location:

Chief of Party:

Lead Line / Sounding Pole Unit of Measure: Meters (This should always be meters!)

Measured by:	**Recorded by:**	**Checked by:**

Graduated Marking (a)	Calibration Measurement (b)	Lead Line Corrector (c = b - a)

Sounding Systems Comparison

Field Unit:

Date & Time	Location (Lat, Lon)	Sounding System Models & Serial Numbers	Raw Depth (m)	Processed Depth (m)	System Operator	Comments
1/15/2005		Non-traditional lead line: FA-LL1 Reson 8101 (Launch 1): DLDG MODIII:	60.0 58.5 59.2	60.0 59.7 60.1	ST GF ST JA CST LM	Annual Systems Certification comparison. Sea conditions calm, 1 ft swell. No corrections necessary.

Multibeam Echosounder Calibration

Field Unit:

Date of Test:

Calibrating Hydrographer(s):

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System:

System Location:

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: pole-mount on port side of vessel

Date of Current Vessel Offset Measurement / Verification:

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

TEST INFORMATION

Test Date(s) / DN(s):

System Operator(s):

Wind / Seas / Sky:

Locality: Chesapeake Bay

Sub-Locality: Tail of the Horseshoe

Bottom Type: sandy

Approximate Average Water Depth: 20 meters

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed

TEST RESULTS
Navigation Timing Error:
Pitch Timing Error:
Roll Timing Error:
Pitch Bias:
Roll Bias:
Heading Bias:
Resulting CARIS HIPS HVF File Name:

NARRATIVE
Briefly and succinctly summarize the MBES Certification Test, focusing on those aspects of the test. Particular attention shall be paid to interpretation of test results, with discussion on residual biases in roll, pitch, heading, and navigation timing error. Any changes to configuration made based on these results shall be described.

Side Scan Sonar Calibration

Field Unit:

Date of Test:

Calibrating Hydrographer(s):

SIDE SCAN SYSTEM INFORMATION

Side Scan System: Klein System 3000

System Location: Launch 1005

TPU Serial Number:

Towfish Serial Number:

Cable Type: stainless steel armored w/ grease termination

Date of Most Recent EED / Factory Checkout:

Date of Most Recent Pressure Sensor Verification (if applicable):

VESSEL INFORMATION

Sonar Configuration: towed

Cable Measurement System (if applicable): Dynapar cable counter

Date of Current Vessel Offset Measurement / Verification:

Date of Current Cable Measurement / Verification (if applicable):

TEST INFORMATION

Test Date(s) / DN(s):

System Operator(s):

Wind / Seas / Sky:

Locality:

Sub-Locality:

Description of Bathymetry: steep

Bottom Type: rocky

Approximate Water Depth:

Description of Target: ping pong ball target

Approximate Target Size: (should be approximately 1m L x 1m W x 1m H)

TEST INFORMATION (continued)
Target Position:
Description of Positioning Method:
Estimated Target Position Error:
Approximate Survey Speed:
Approximate Towfish Altitude:

DATA ACQUISITION INFORMATION		
Line Number	**Heading**	**Speed**

TEST RESULTS
Number of Passes on Target:
Succesful Target Detections:
Mean Detected Position:
Distance from Mean Position to True Position:
Approximate 95% Confidence Radius:

NARRATIVE
Briefly and succinctly summarize the SSS Certification Test. Particular attention should be paid to interpretation of test results, with discussion of any correlation between target detection or positioning error and side scan pass direction, range, or channel. Any changes to configuration made based on these results shall be described.

Appendix 2

Pre-Survey Planning

CONTENTS

Basic Water Level Station Equipment Checklist

Critical Information
__________ determine local magnetic variation at site:
__________ determine exact UTC time:

Gauge - Separate Items
__________ gauge
__________ tarp
__________ nitrogen Tank
__________ 2 batteries
__________ GOES antenna
__________ tripod
__________ GOES cable
__________ solar Panel
__________ solar Cable
__________ computer with RS232 connector

Gauge - Bag
__________ swagelock fittings
__________ nitrogen regulator
__________ snoop
__________ compass
__________ inclinometer
__________ parachute cord
__________ crescent wrench
__________ 9/16, 5/8, 11/16, & 1 1/8 wrench
__________ lag shields (1/2"; 3/4" hole)
__________ eyebolts (1/2" ; 3/4" hole)
__________ orifice cutter
__________ plastic zip ties

Staff - Separate Items
__________ graduated staff
__________ extra support lumber
__________ electric wood drill and bits

Staff - Bag
__________ wood saw
__________ hand drill and bit
__________ lag bolts - various lengths
__________ lag shields (1/2"; 3/4" hole)
__________ machine bolts - various lengths
__________ spacers
__________ washer and nuts
__________ angle irons
__________ hammer
__________ wire snips (dykes)

Leveling - Separate Items
__________ level
__________ rods
__________ tripod

Leveling - Bag
__________ lumber crayon
__________ IPAQ w/ Newwiz 2.0
__________ extra battery for IPAQ
__________ pencils, pens & calculator
__________ steel tape
__________ level bubbles
__________ turtle

Orifice - Separate Items
__________ Orifice Tubing w/ Orifice
__________ Orifice Plate
__________ chain

Orifice - Bag
__________ separate Orifice
__________ Hose clamps
__________ Plastic zip ties
__________ wire snips (dykes)
__________ crescent wrenches
__________ box wrench
__________ flat screw driver
__________ hammer
__________ orifice cutter
__________ lagbolts - various lengths
__________ lag shields (1/2"; 3/4" hole)
__________ eyebolts (1/2" ; 3/4" hole)

Diver - Separate Items
__________ first aid
__________ oxygen
__________ Back Board
__________ Save a Dive Kit
__________ Dive Bag

Diver - Pneumo Bag
__________ pneumatic drill
__________ pneumatic drill bits
__________ pneumatic hose

Diver - Toolbag
__________ Hose clamps
__________ Plastic zip ties
__________ wire snips (dykes)
__________ crescent wrenches
__________ box wrench
__________ flat screw driver
__________ hammer

Benchmark - Separate Items
__________ 2 Bosch drills
__________ extra Bosch batteries
__________ Bosch charger
__________ fresh water
__________ cement

Benchmark - Bag
__________ benchmarks
__________ hammer/ mallet
__________ stamping kit
__________ plastic bags
__________ measuring tape
__________ camera (w/ extra batteries)
__________ handheld GPS

Appendix 3

Data Acquistion

CONTENTS

The following instructions are the standard setup for HYPACK and HYSWEEP devices. There are two sets of device setups that need to be configured when using Hysweep. One is in Hypack Hardware, which includes navigation, motion, gyro and AIS, and one is in Hysweep Hardware which includes navigation, motion and bathy (See *Diagram 1*). It is also important to setup the POS Ethernet Realtime to be compatible with this setup.

1.0 POS M/V

** Items in this controller should only be changed by experienced users with the unit. If you are new to POS you should only verify that the items addressed below are correct and then you may start logging.*

*** Reminder: If you want to change anything in the logging control windows you must be connected first.*

1.1 Ethernet Realtime Logging

ONLY the following message groups should be selected: 3, 7, 20, 102 and 111. When you save and exit, the program will give you a warning about not selecting 'Group10'. Override this warning. We do **NOT** want group 10 to be sent real time.

2.0 HYPACK

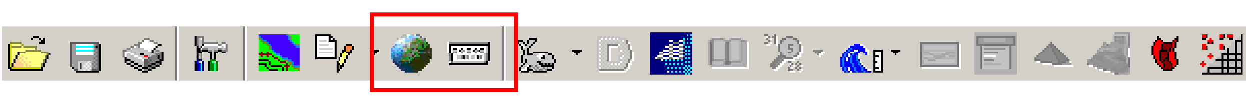
1.1 PROJECT MANAGER

1.1.1 In the Administer Window: Select File > Project Manager

1.1.2 Select New Project – Name accordingly

1.2 Geodetic Parameters (UTM Zone)

When making a new project it is very important to select the correct UTM Zone. Ellipsoid is WGS-84



1.3 HYPACK HARDWARE CONFIGURATION

Devices are very important. Without them we will not get the correct information that we need in order to survey.

1.4 ADD DEVICES/ SET UP

Click on the Add Device button. Add the following three devices.

1. Applanix POS M/V Network (posmv.dll)
2. Hysweep Interface (HYSWEEP.dll)
3. AIS (ais.dll)

Now that you have added your devices, we need to configure your devices and make sure your settings are correct.

1. **Applanix POS M/V Newtork (posmv.dll)** – (mimic *Image 1*)
   a. Be sure that Position, Heading, Speed and Heave are all check off

b. Connect – Network Port
   - Protocol – UDP
   - Role – Client
   - Host – IP address of POS (129.100.1.231)
   - Port – 5206 – always the same for the POS M/V

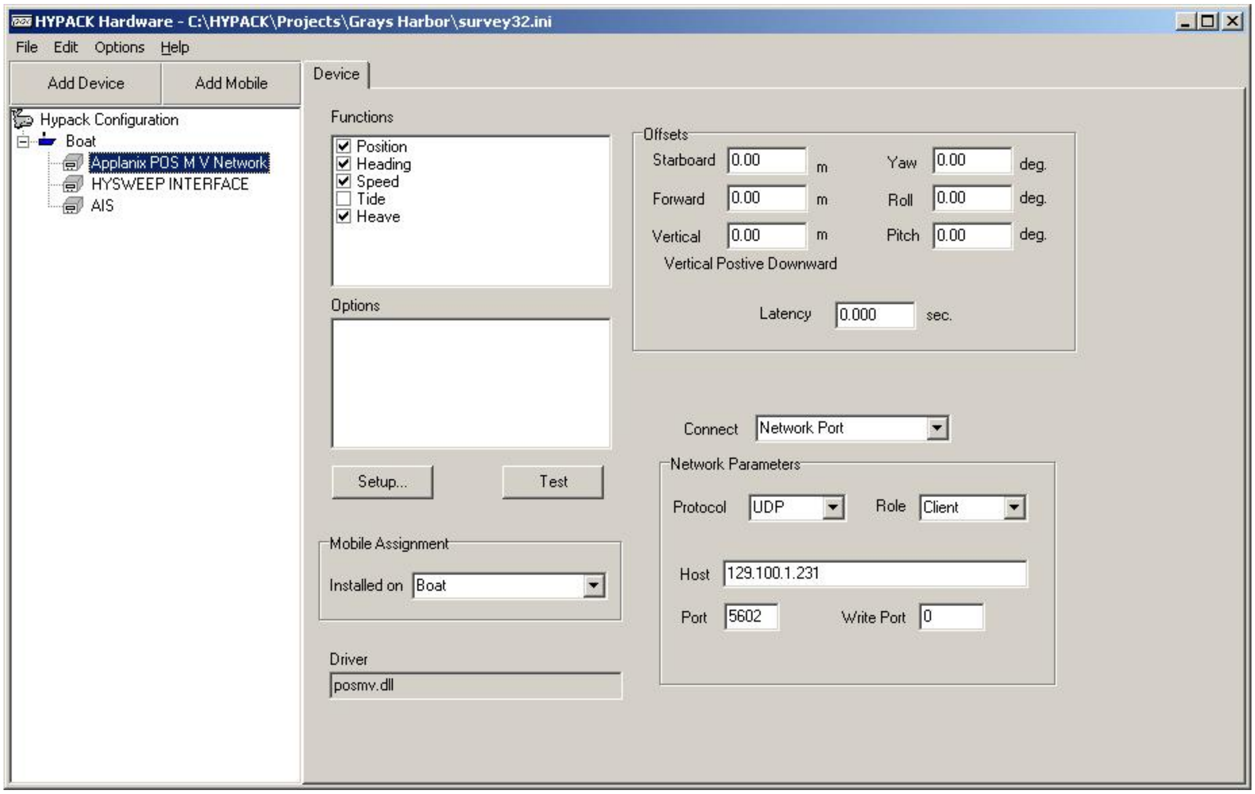


Image 1. Applanix POS M V Newtork

c. Click on the setup button - (*Image 2. POS MV Setup* Window will pop up)

- The "Use PPS signal for timing" should be <u>unchecked</u>
- IT IS VERY IMPORTANT TO HAVE "Use POS M/V time-tags even when not synchronizing" <u>TO BE CHECKED.</u>
- Select
  – record multibeam frame data (group 102)
  – Get heave from group 102
  – Get solution status from group 20 (POS M/V version 4)

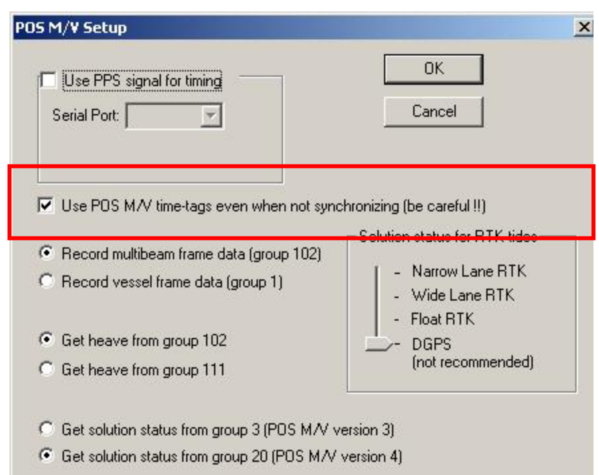


Image 2. POS M/V Setup

2. **<u>HYSWEEP INTERFACE (HYSWEEP.dll)</u>** – no setup or connection required
   a. Be sure that 'depth' function and 'Use for matrix update' are checked off (see image 3)

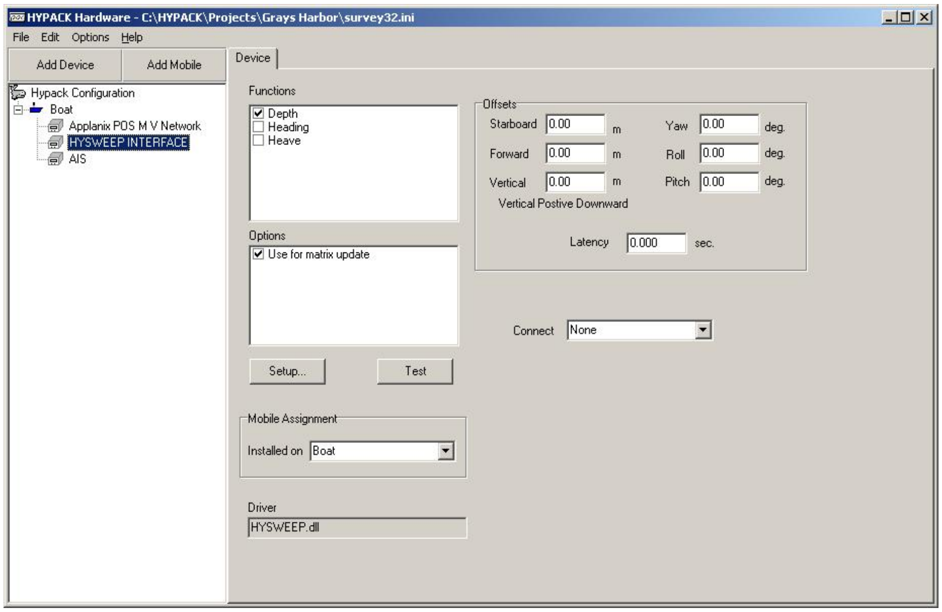


Image 3. HYSWEEP INTERFACE

3. **<u>AIS (ais.dll)</u>** – If you are equipped with an AIS
   a. Connect – Serial Port COM#, 9600, 8, 1, None, None

After all of the Hypack devices are setup, setup your Hypack Configuration and Boat Configuration.

<u>Hypack Configuration</u> – see window below - *IN THIS SET UP IT IS VERY IMPORTANT TO BE SURE THAT THE DEVICE TO SYNC CLOCK WITH IS "Applanix Pos MV Network"*

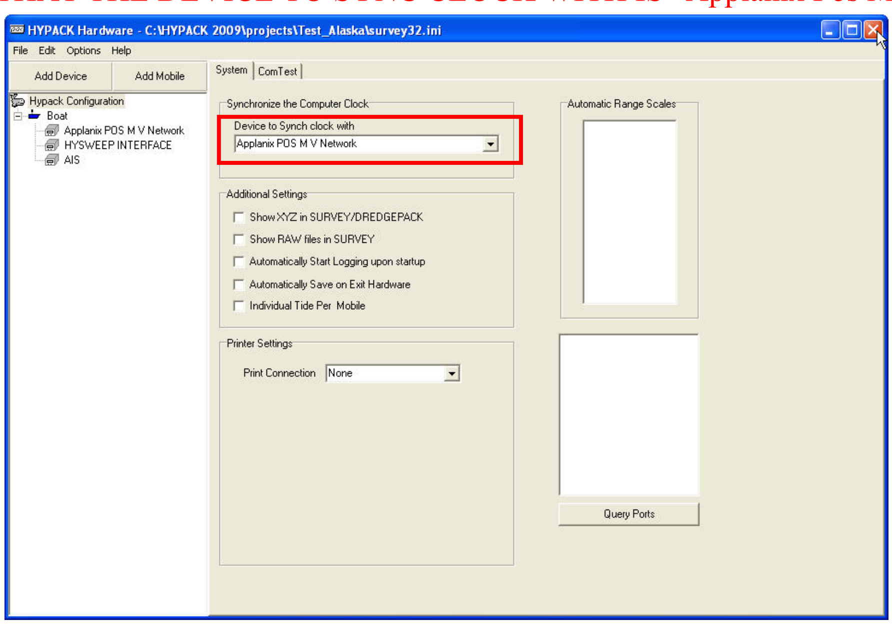


Image 4. Hypack Configuration

<u>Boat Configuration</u> – See window below – Check that the correct device (source) shows up next to each information type. It is on this screen that you can change the tracking point of the boat, ie, you want the real time swath to be originating from the transducer and not the center of the boat.

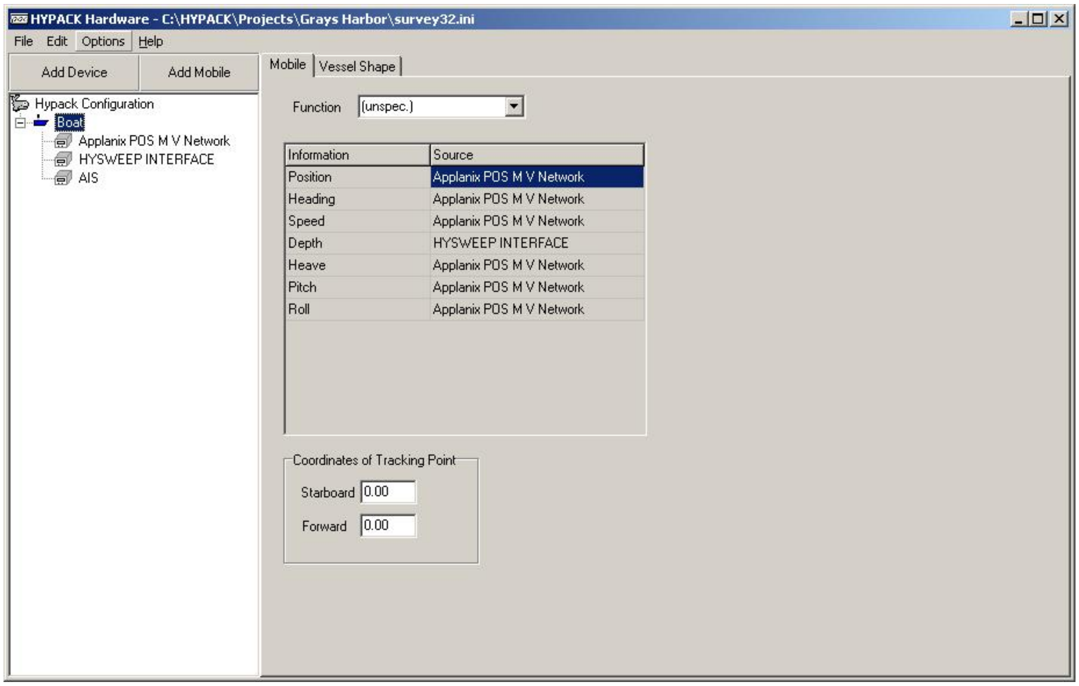


Image 5. Boat Configuration

1.5 TESTING DEVICES

- Testing of devices should be conducted every time Hypack is opened.
- #1 Device to check is the Applanix POS M/V Network (posmv.dll)
  1. Click on the Test button. The screen to the right will pop up.
  2. Ensure that all of the categories are populated, changing and seem to be correct.
     a. IIN Mode – **RTCM** (this is what you want to see)
        <u>C/A (Course Acquisition)</u> – ok, some places in Alaska might not have a strong signal.
        <u>N/A</u> - not good, might have the wrong beacon chosen or the beacon is down.
     b. Time source – **Group 7** – ensures that you have your Hypack Configuration Device to sync set correctly.

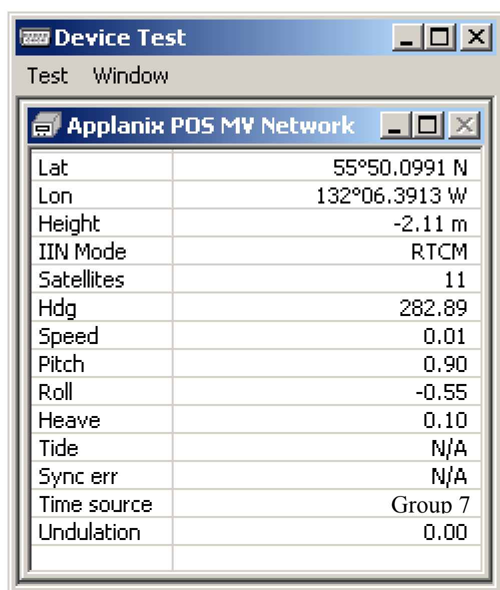


Image 6. Hypack Navigation Window

Congratulations! You have now setup the Hypack Hardware Portion of this configuration.

3.0 HYSWEEP HARWARE CONFIGURATION

Hysweep > Hysweep Hardware

Like Hypack devices, Hysweep devices are very important. This setup is taken into consideration when converting your data. There are three devices that must be setup in Hysweep Hardware.

*Must have windows firewall disable

3.1 SETUP / CONNECT

Under the Manufacture / Model tab click on the following device then click the Add button. The device will be installed and shown by populating in the screen on the right side of the window under Installed.

1. Hypack Navigation
2. Applanix POS/MV Network
3. The appropriate Sonar Device - Reson Seabat 7125, 8101or 81xx(Network), etc.

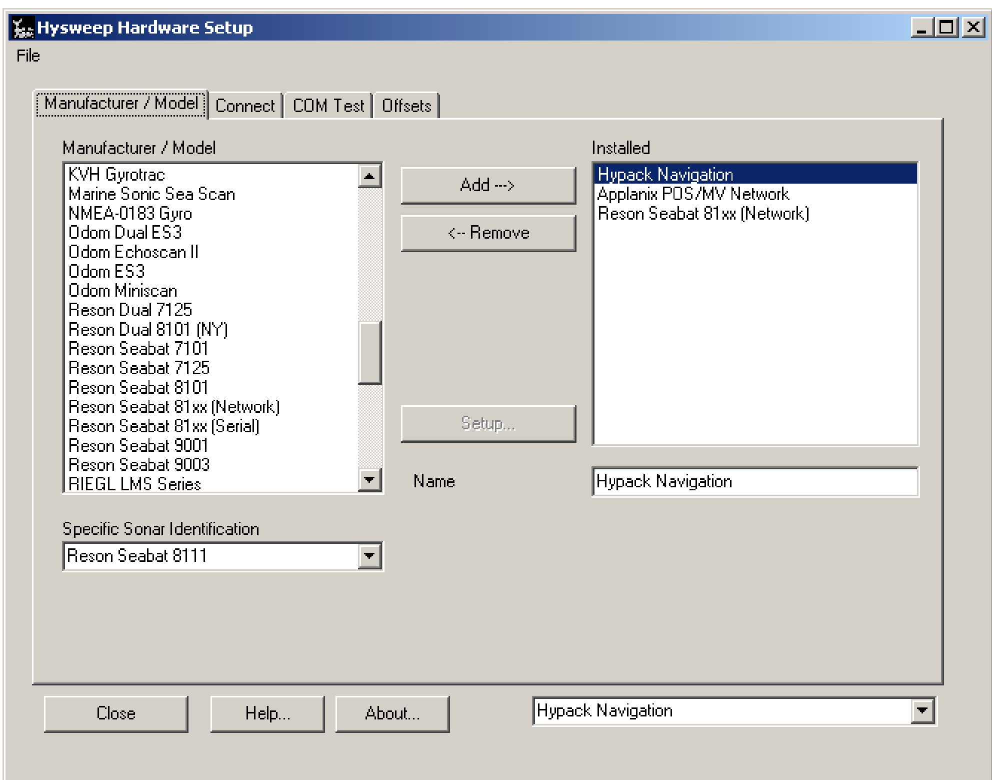


Image 7. Hysweep Hardware Setup

1. **Hypack Navigation –** does not need a setup or any settings changed under the connect tab.

2. **Applanix POS/MV Network** – does not need any changes in setup.
   Does need some settings changed in the connect tab. (see *Image 8* below)
   a. Select the Connect tab

b. Make sure that Applanix POS/MV Network is populated at the bottom right hand of the window.
c. Enabled box gets checked
d. Port – 5602
e. Internet Address – 129.100.1.231

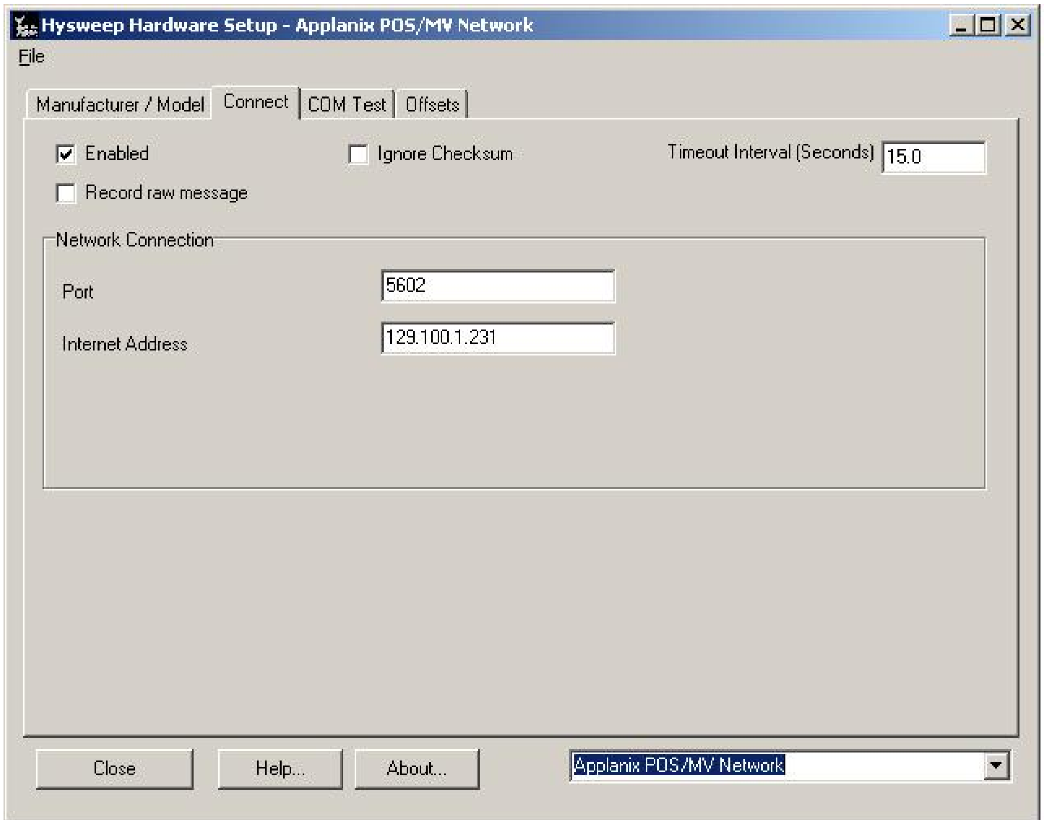


Image 8. Hysweep Hardware Setup - Applanix POS M/V Connect tab

3. **Sonar (RESON 81XX)** – needs changes in the setup and Connect tab.
   a. Select the Correct Model
   b. Specify the correct identification (located at the bottom left hand side of the screen)
   c. highlight the sonar listed under Installed

- **Setup**
  a. click on the 'Setup…' button (*Image 9* will pop up)
  b. Select 'Side Scan Option'
  c. Select 'Use Snippets' if the project calls for it.
  d. Network Driver, COM Port for Time Sync (9600 Baud) – set to NONE

- **Connect Tab** (*Image 10*)
  a. Select 'Enable' and 'Ignore Checksum' boxes.
  b. Under Network Connection - enter the port and IP address of your sonar.

Refer to the ship and launch wire diagrams for sonar specific connections.
*Make sure you have the IP address of the sonar and not of the computer NIC Card.

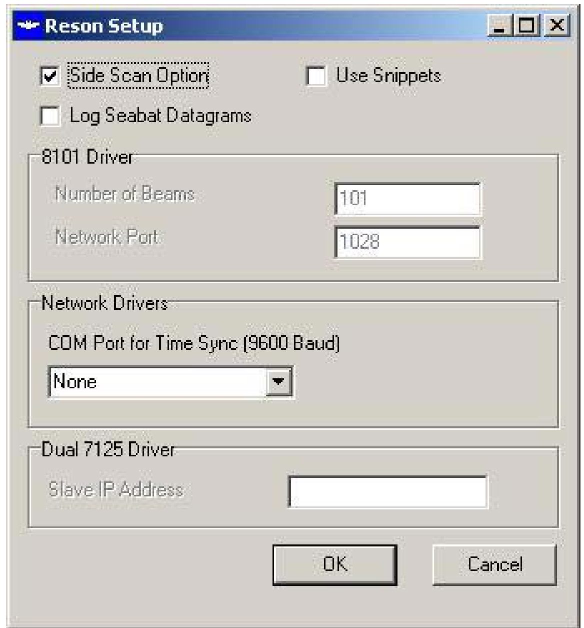


Image 9. Sonar Setup (Reson)

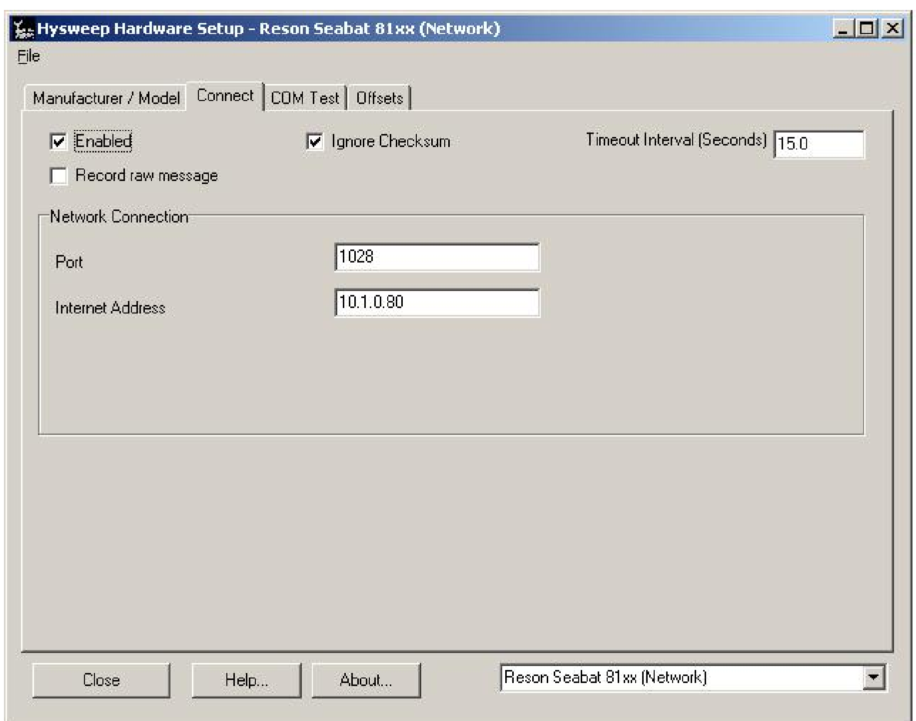


Image 10. Sonar Connect Tab (Reson)

Congratulations! You are now ready to survey! ☺

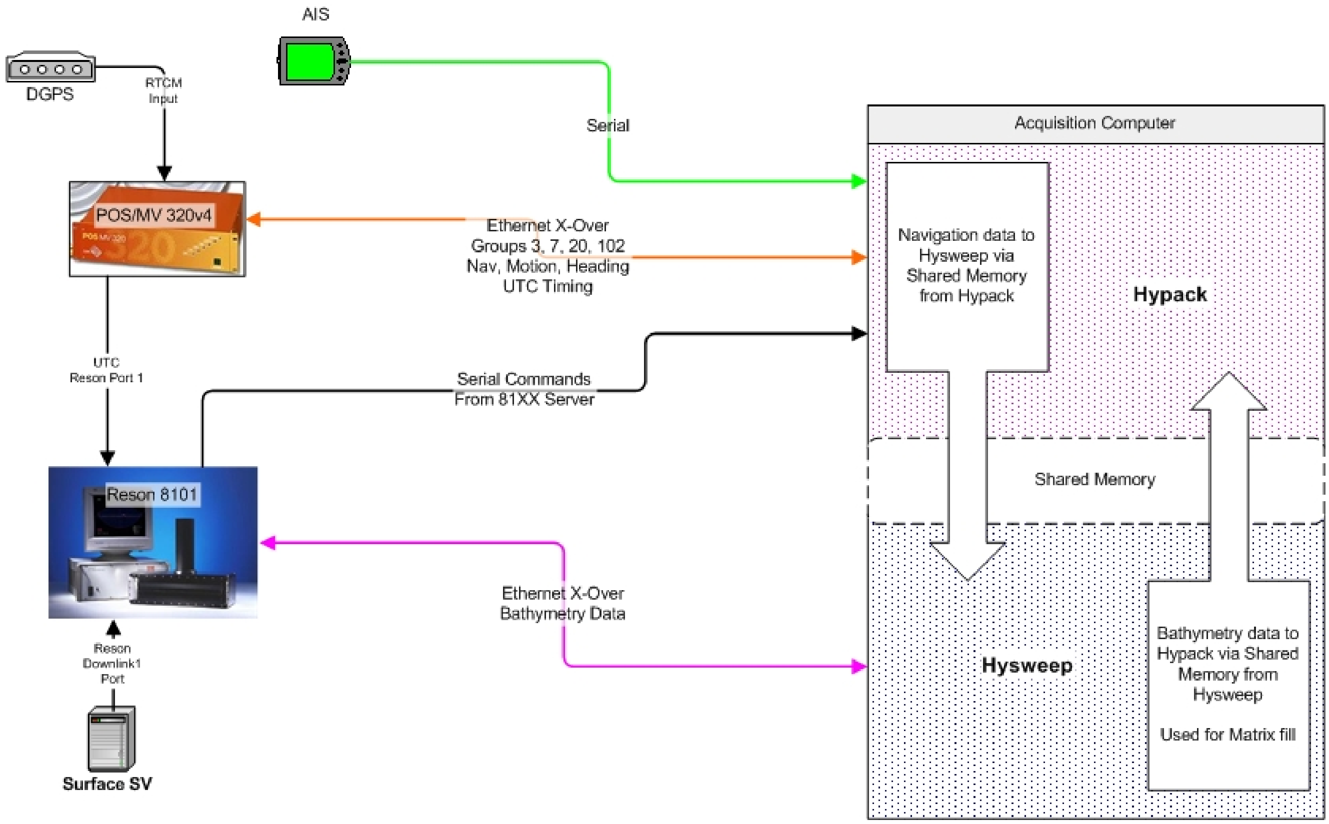


DIAGRAM 1. General Box Wiring Diagram of the Hypack/Hysweep Setup

DIVER LEAST DEPTH GAUGE MODEL III

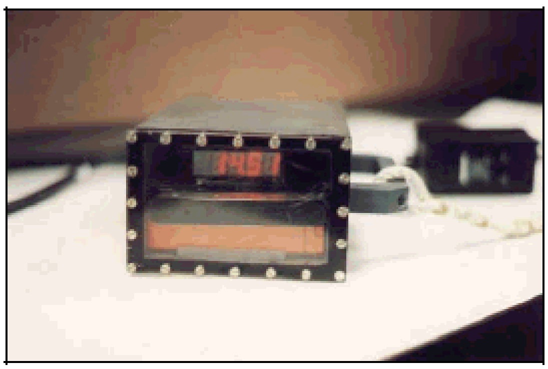
GENERAL

The MOD III Diver Least Depth Gauge (DLDG) consists of a Micro Gauge Corporation precision absolute pressure sensor and a PTC Electronics Incorporated Model D2000 pressure readout assembly, with rechargeable batteries, housed in a specially constructed rectangular water-tight enclosure. The following are used in conjunction with the operation and care of the instrument: battery charger, underwater plug, special processing software, Sea-Bird Electronics SEACAT CTD Profiler, and barograph. **Neither the profiler nor the barograph is provided with the instrument; rather they must be resident on the ship**.

PHYSICAL FEATURES

Figure 1 is a picture of the front of the enclosure of the MOD III DLDG. The face plate on the enclosure is clear to allow the LED display to be read (in this case, 14.51 psia).

Figure 1



Front View of a Diver Least Depth Gauge Model III

Figure 2 also shows the front of a MOD III DLDG. Shown to its left is an InSitu MiniTroll instrument, a handheld absolute pressure gauge.

Figure 2

The rear face of the MOD III enclosure contains the bulkhead electrical connector and the pressure port. There is a 7 cm vertical offset distance between the position of the pressure port and the bottom of the instrument case. Note that this offset is applied as a correction by program VELOCWIN in the computation of the least depth. Therefore, in order to obtain a correct value for the least depth, the MOD III gauge should be placed on top of the diver-determined least depth point and held level so that the LED readout is upright (as shown in Figures 1 and 2).

THE GAUGE IS TO BE CONNECTED TO THE BATTERY CHARGER WHEN NOT BEING USED ON A DIVE OPERATION. This is to increase the reliability and availability of the unit. A fully charged battery should give the gauge approximately 10 hours operating time. For the instrument to be returned from low voltage to its fully operational condition, the battery must be on charge for 18 hours.

For the InSitu MiniTroll, the pressure port is 2.9 cm from the bottom tip of the probe. The bottom tip is the end opposite the watertight screw cap covering the data port. The 2.9 cm offset is applied as a correction by program VELOCWIN in the computation of the least depth. Therefore, for accurate results, the MiniTroll should be held upright with the bottom tip of the wand placed on the user-determined least depth point.

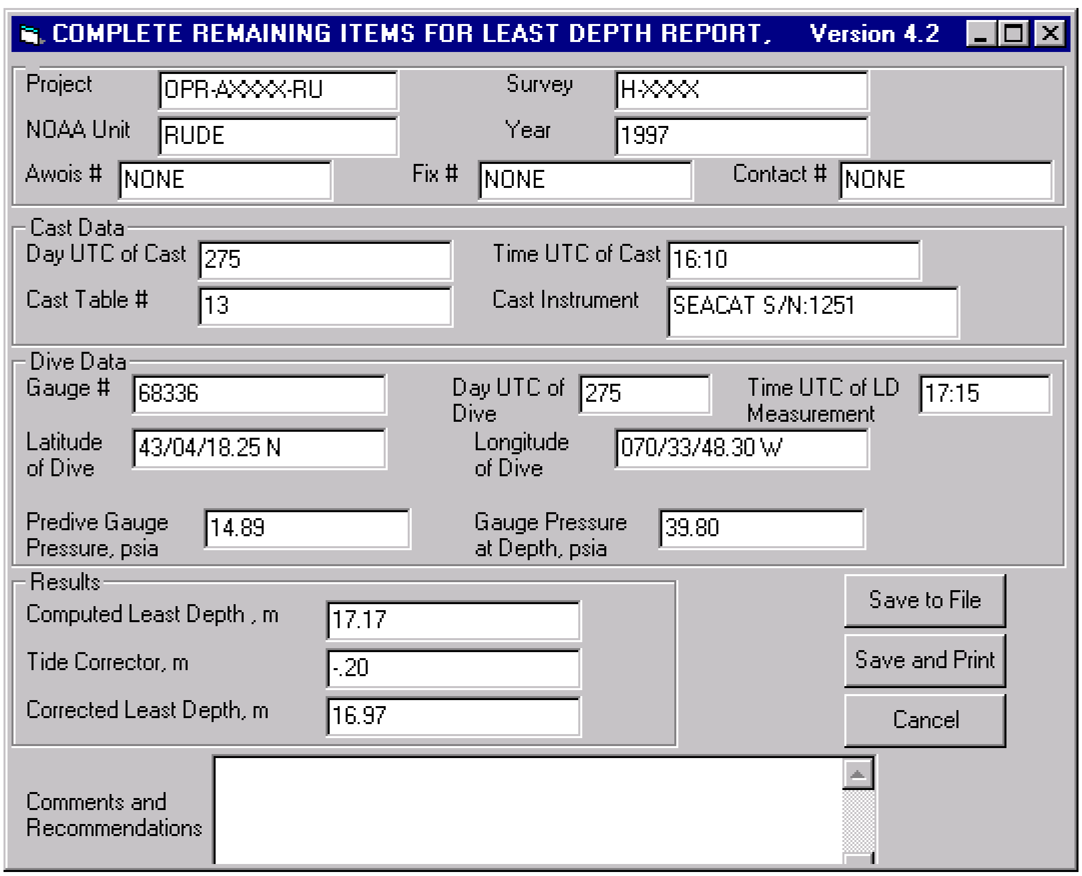
SOFTWARE

The Diver submenu of program VELOCWIN provides two options to use in conjunction with the Diver Least Depth Gauge:

(1) Least Depth Report
(2) Daily DQA – Diver Gauge.

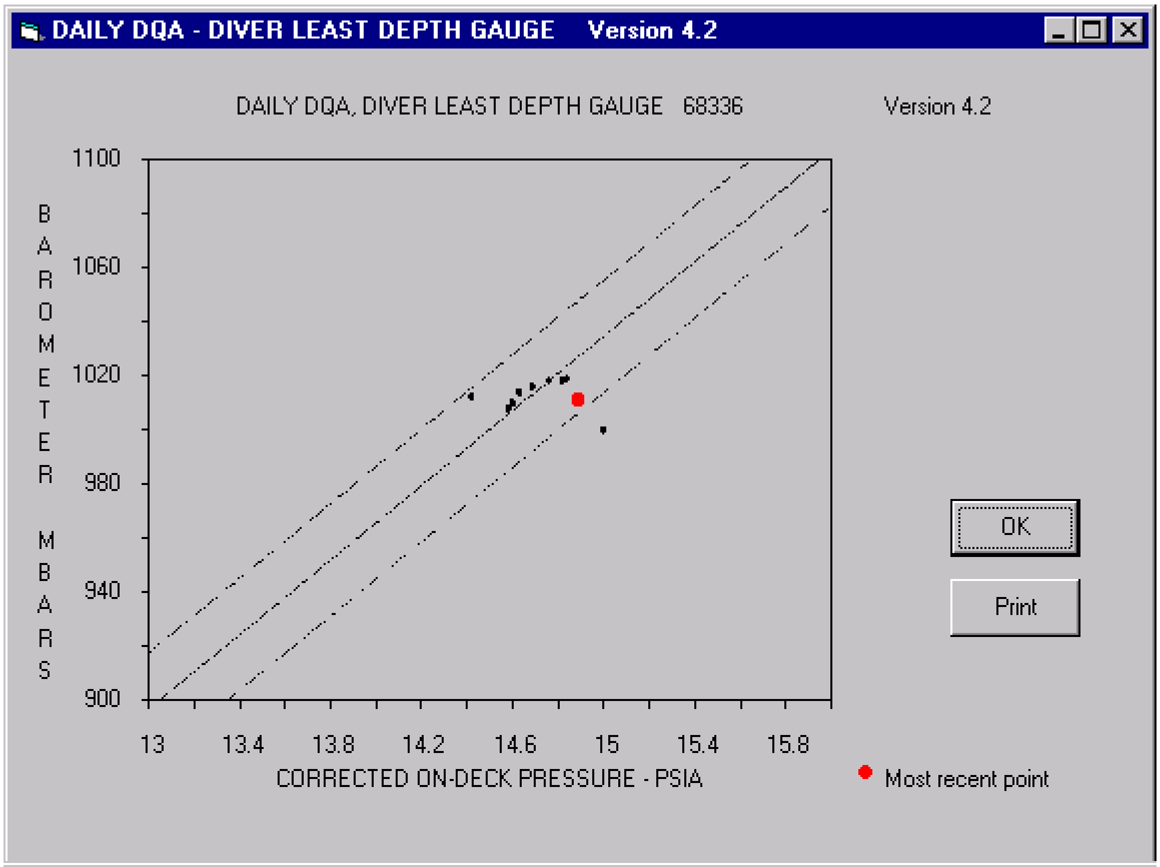
The Least Depth Report option prompts the user for several inputs including the pressure on-deck and at the user-determined least depth point. Using these two values, the calibration data for the DLDG, and the data from a Sea-Bird SEACAT CTD cast taken in the vicinity, VELOCWIN computes the least depth of the submerged object. The results of this option are shown in Figure 3 which may be printed out to obtain a hard copy record of the dive and the least depth result.

Figure 3



The Daily DQA option is a data quality assurance procedure for the DLDG. It prompts the user for the on-deck DLDG pressure in psia and the barograph reading in mbars. Using these values and the gauge's calibration data, VELOCWIN determines if the instrument is operating within acceptable bounds. The results are a running log file (DIVERDAILYDQA.DAT) and a graphical display of the relationship between the ship's barograph and the DLDG. Figure 4 is an example of the graphical display.

Figure 4



The calibration file for the gauge has filename, SN.CAL, where SN is the serial number of the gauge (example: 68332.CAL). The default location for this file is C:\VELOCITY, the directory of program VELOCWIN. If it is stored elsewhere, VELOCWIN will prompt the user for the location.

DATA QUALITY ASSURANCE

The DAILY DQA option requires that the on-deck DLDG pressure be entered in psia to two decimal places and the barograph reading be entered to the nearest millibar.

The LED readout is absolute pressure in units of pounds per square inch. This on-deck reading should be in the region of 14.70 psia. The reading will rise and fall with the local atmospheric pressure, along with variations in the distance below the water surface. The nominal depth equivalent of a 0.01 psia change in pressure is 0.5 cm. If the gauge is subjected to horizontal acceleration in a line between the pressure port and the LED readout, there may be a small change in the pressure reading.

The DAILYDQA option should be run each day. It should also be run before and after each day's dive operation to provide a pre- and post-dive record. At the end of each field season and any other time that the gauge is returned to a Marine Center, the running log file, "\VELOCITY\DIVERDAILYDQA.DAT", must be returned with the gauge.

The gauge uses a built-in, approximate calibration curve to derive the pressure values shown on the LED readout. The more accurate calibration curve, by gauge serial number, is employed by the VELOCWIN program to achieve high accuracy results. The data quality assurance test might not indicate an exact one-to-one relationship with the ship's barograph, but the relationship should be reasonable and regular and fall within the acceptance bounds shown in the DAILY DQA graphical display.

DIVE OPERATION

As shown in Figures 1 and 2, the handle is attached to the gauge such that the unit must be held in the diver's right hand in order for the numerals in the LED readout to be upright. The unit should be placed on top of the diver-determined least depth point and held close to level. Below the water's surface, a depth error, in centimeters, of approximately 15*SIN(tilt angle) will result from non-level operation. When the unit is at depth and fixed on the least depth point, the pressure readout will vary as a result of any overhead surface waves. The peak to peak variation due to these waves may occur over a period from 1 to 8 seconds. Therefore, it is necessary for the diver to observe the LED readout for 10 seconds or more to improve the diver's estimate of the mean pressure.

On days when dive operations are to be conducted, the gauge will be disconnected from the battery charger. The exposed electrical connector on the instrument must be capped with the underwater connector which is provided. It is not necessary to disconnect the battery charger from the ship's A/C supply. There are three pins on the electrical connector, one of which is larger than the others. The underwater plug has a flat spot over the large pin. Care should be taken when inserting the charger cable plug or the underwater blanking plug onto the instrument to be sure that the connector is correctly orientated relative to the pins of the electrical connector on the rear of the enclosure.

Previous to each dive, the pressure reading on the instrument must be observed with the unit out of the water and appropriately recorded. A diver will carry the unit on the dive to locate and measure the least depth on a designated object. The accurate least depth is determined via head pressure at the diver-designated least depth point, in conjunction with the knowledge of the local vertical density profile. The head pressure is the difference between the on-deck (pre-dive) pressure reading and the pressure observed by the diver at depth. The density of the water column is obtained from the Sea-Bird SEACAT CTD cast taken in the vicinity. Running the Least Depth Report option of VELOCWIN computes the head pressure and converts it to the reported least depth.

Upon completion of a day's dive operations, the Diver Least Depth Gauge must be washed with fresh water and wiped dry. The underwater plug must be removed from the rear of the gauge and stored in a safe place. Finally, the battery charger should be connected to the gauge being careful of the connector orientation.

SUPPORTING DATA

The local density profile must be independently measured in the vicinity of the dive site with a SEABIRD SBE-19 or SBE-19Plus SEACAT Profiler and processed via the VELOCWIN program. The cast should be taken in accordance with the specific SEACAT instructions, which are documented separately. However, **IT IS VERY IMPORTANT THAT THE SEACAT SHOULD BE POWERED-ON AND HELD ON-DECK FOR AT LEAST THREE MINUTES PREVIOUS TO LOWERING THE SEACAT INTO THE WATER.**

Complete instructions for taking a SEACAT cast are available from the VELOCWIN Help submenu under Precast Setup

CALIBRATION

Each Diver Least Depth Gauge will require an annual calibration before deployment for the field season. At the end of the field season, a post-deployment verification must also be performed. Post-deployment verification and pre-deployment calibration may be performed simultaneously. The gauge must be returned to the Marine Center for forwarding to the manufacturer for calibration. Once calibration is accomplished, a hardcopy calibration report will be provided for each gauge. A copy of the report must be provided to HSTP/CSDL in order for an extended calibration curve to be generated (to accommodate deep dives). HSTP provides the extended calibration curve as a digital file named SN.CAL where SN is the DLDG serial number. The file is disseminated to all field units.

CALIBRATION GUIDELINES

The gauge contains a 100 psia pressure transducer. Calibration between approximately 13 and 50 psia is critical for accurate least depth measurements. A data set of fourteen points, with the first point being below ambient pressure, the next point at ambient pressure, the next seven points at 1 psia increments above ambient pressure, and the remaining points at 5 psia increments will insure sufficient accuracy. Replacing exhausted batteries will not effect calibration; however, any circuit repairs will require complete gauge calibration.

Calibration is performed by:
PTC Electronics Inc.
45 Whitney Road, Suite B9
Mahwah, NJ 07430
Attn: John C. Kicks

PROBLEMS

If the results of the DAILYDQA test fall outside the acceptance bounds, this fact should be noted to the Marine Center and arrangements made for the gauge to be replaced and/or repaired. In addition, inform the Marine Center if any other irregular performance of the DLDG arouses suspicion.

USER'S GUIDE
FOR
GPS OBSERVATIONS

Updated March 2007

Requirements and Development Division
Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration

TABLE OF CONTENTS

USER'S GUIDE FOR GPS OBSERVATIONS

1.0 Introduction

This User's Guide for Global Positioning System (GPS) Observations for the tidal and water level station bench marks is prepared to support the Center for Operational Oceanographic Products and Services (CO-OPS) GPS Implementation Plan. The field observation procedures are developed in collaboration with the National Ocean Service (NOS), National Geodetic Survey (NGS), and consist of slight modifications of NOAA Technical Memorandum NOS NGS-58, Version 4.3, as described below, to obtain relative accuracy in connecting water level stations to the International Terrestrial Reference Frame (ITRF) and the North American Datum of 1983 (NAD 83) coordinate systems. Modifications made to NOAA Technical Memorandum NOS NGS-58 guidelines and requirements involve the length of the GPS observations required, in this document. This Guide must be used in conjunction with NGS-58 for collecting the GPS data at water level stations.

It is assumed that the field personnel are familiar with the basic operating principles of the GPS equipment, the cable connections and the antenna/tripod setup procedures. A detailed discussion of GPS processing software and processing procedures is outside the scope of this Guide. GPS data collected by CO-OPS or CO-OPS' contractors for the National Water Level Observation Network (NWLON), for hydrographic and photogrammetric surveys either by NOS Office of Coast Survey (OCS) and NGS field parties will be submitted to NGS for data processing – "blue-booking" is a term used to describe this processing according to the Input Formats and Specifications of the National Geodetic Survey Database, Appendix L – Guidelines for Submitting GPS Relative Positioning Data.

All GPS data must be collected as per NGS specifications and as described later in this document and processed first using NGS Online Positioning User Service (OPUS). All GPS data and documentation shall be submitted to CO-OPS, which will then be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

1.1. Reference Documents

The following reference documents are referred in various sections of this document.

(1) "CO-OPS GPS Observations Implementation Plan, January 2003".

(2) "NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3".

(3) "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987".

(4) "Standards and Specifications for Geodetic Control Networks", Federal Geodetic Control

Committee, September 1984.

(5) “Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005”

2.0. Equipment and Setup

High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites. A choke ring antenna is preferred; however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas models should be used during the entire observing sessions. If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied. This is extremely critical for obtaining precise vertical results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls-eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing a Height of Instrument (HI) “blunder” during the post-processing of the data. There are situations where it may be necessary to use the adjustable precise GPS antenna tripod, such as when a bench mark is elevated above ground level or when using air transportation. The center pole is adjustable on this tripod; therefore, if not fully extended to the 2 meter position, the antenna height is measured with a steel tape (several times) and entered into the receiver and onto the GPS Observation Log Sheet. In fact, even in the 2 meter position, it is recommended that the adjustable tripod be measured to verify the length. There is a screw-on point at the bottom of the center pole of both - the fixed and adjustable tripods - that must be inspected each time the tripod is setup to ensure that the point is tight and not bent. The tripod must be stable during observations; therefore, the tripod legs must be secured, preferably with sand bags.

Antenna set-up is critical to the success of the project. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbness is determined. Plumbing bubbles must be shaded for at least 3 minutes before checking and/or re-plumbing.

The manufacturer, model, and complete serial numbers of all receivers and antennas must be included for each occupation on each station/bench mark observation log sheet as shown in Figure 3.

3.0 Geodetic connections and datums relationship

Water level datums are local vertical datums which may change considerably within a geographical area. A geodetic datum is a reference surface relative to which heights are determined. The North American Vertical Datum of 1988 (NAVD 88) is the accepted vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationship of tidal datums to NAVD 88 has many hydrographic, coastal mapping and engineering applications including monitoring sea level change and the deployment of GPS electronic chart display and information systems, etc.

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at http://www.ngs.noaa.gov. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has at least one geodetic bench mark located nearby as stated below for Sections “NAVD 88 Level Tie” and “NAD 83 GPS Tie” requirements. NAVD 88 heights for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to NOAA Technical Memorandum NOS NGS-58). At the present time, GPS ellipsoid heights conforming to the 2 cm accuracy standards are required for all GPS survey projects.

A connection to the geodetic datums at a water level station enhances the value of the tidal data, allowing comparison with other data sets. The geodetic network essentially serves as a global reference datum to which all tidal datums can be referenced.

The connection to geodetic datums involves the following three ties:

(1) NAVD88 Level Tie
(2) NAD 83 GPS Tie
(3) NAVD88 GPS Tie

3.1. Level Connections

3.1.1. NAVD88 Level Tie

At all water level stations, a valid level tie to at least two Geodetic Bench Marks (GBM) is required on each set of levels, where appropriate marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At many NWLON stations, the Primary Bench Mark (PBM) is a GBM. At the majority of NWLON stations, there are two or more tidal bench marks that are also GBM, thus increasing the chance that the geodetic level tie will be valid.

Make a Second-Order, Class I tie for all NWLON stations in the conterminous United States and Caribbean Islands. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas.

At stations supporting hydro or other special projects, the tie shall be consistent with the accuracy of the levels required for the project.

Information on performing a valid level tie is provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:
http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5

Also, *Section 3.4 of "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987"* provides information regarding how to perform a valid level tie.

The Second-Order, Class I tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs is required at each site.

A note shall be made in the remarks of the leveling section of the Site Report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If the NWLON water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the level tie requirement is waived.

3.1.2. Leveling at Continuously Operating Reference Stations (CORS)

For any NGS CORS reference bench mark that is located within 1.6 km (1 mi) leveling distance of a water level station Data Collection Platform (DCP), a leveling connection shall be made to the tidal bench marks in the water level station network every two years.

Information about NGS CORS can be obtained at http://www.ngs.noaa.gov/CORS/.

As of 2007, there are a limited number of water level stations in this category, but NGS and CO-OPS are attempting to secure funding to establish additional co-located sites to support long-term sea level trends monitoring.

3.2. GPS Connections

3.2.1. References

Static GPS observations shall be performed at water level stations in accordance *with "NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3"*. These guidelines are written for establishing GPS derived ellipsoid height accuracy standards of 2 cm for all NWLON, PORTS®, hydrographic/Photogrammetry survey projects, COASTAL projects, and special project applications.

3.2.2. GPS Observations - Goals and Planning

Precise positioning of NWLON stations in a global geocentric reference framework is needed to support NOS marine safe navigation and height modernization projects, in addition to monitoring vertical crustal motions for absolute sea level and global climate change studies.

CO-OPS shall initiate a program of making periodic GPS observations at water level stations, as resources permit. CO-OPS activities shall be coordinated with NGS activities for best use of available resources.

GPS technology and procedures shall be implemented in the operational plan:

(1) To support the development of a seamless, geocentric reference system for the acquisition, management, and archiving of NOS water level data. This will provide a national and global digital database, which will comply with the minimum geo-spatial metadata standards of the National Spatial Data Infrastructure (NSDI) and connect the NOS water level datums to the NGS NSRS;

(2) To establish transformation functions between NOS chart datum Mean Lower Low Water (MLLW) or Low Water Datum (LWD) in the Great Lakes, and the geocentric reference system to support NOS 3-dimensional hydrographic surveys, the implementation of Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum transformation (VDatum tool) and tidal datum models. Integration of GPS procedures will support the development of tidally-controlled Digital Elevation Maps and Models for use in programs such as marsh restoration.

(3) To support water level datum transfers by using GPS derived orthometric heights.

(4) To monitor crustal motions (horizontal and vertical) to support global climate change investigations.

The GPS surveys should be scheduled during routine annual maintenance trips to NWLON or PORTS® stations and during the installation of secondary and tertiary water level stations to support the survey projects, U.S. Army Corps of Engineers (USACE) projects, COASTAL project stations, tsunami stations, and special purpose surveys. CO-OPS shall continue to coordinate the GPS occupation of water level network bench marks with NGS, USACE, and the National Geospatial-Intelligence Agency (NGA), as appropriate.

GPS-derived orthometric heights can be accurately determined and used for water level datum transfers according to the following criteria: (a) use the established guidelines for 3-D precise relative positioning to measure ellipsoid heights; (b) properly connect to several NAVD 88 bench marks; and (c) use the latest high-resolution modeled geoid heights for the area of interest. In many remote locations, the use of GPS-derived orthometric heights for datum transfer will be more efficient (timely) and more cost-effective than the use of conventional differential surveying techniques and may, under certain circumstances, preclude the installation of additional water level stations to establish a datum.

As specified in the Annual Project Instructions, Annual Station Specific Requirements, or in the contract documents, installer shall be required to perform GPS observations at each water level station at specified intervals over time, depending on the rate of sea level rise in that water area of the coast.

As of March 2007, 20 NWLON stations have been identified where annual GPS observations are required because of the sea level rise in those areas. These 20 NWLON stations – 8 in Alaska and 12 in the Gulf of Mexico – will be identified in the annual Project Instructions. The rest of the NWLON stations require GPS observations every five years. These guidelines will be updated as GPS technology improves and the policy or regulations change in the future.

3.2.3. Static Surveys

Static GPS surveys shall be conducted on a minimum of one bench mark at each water level station, according to the priority levels below. Generally, one mark at each station is designated as the GPS mark and observations shall be made to that mark (as per the required GPS observation frequency) unless otherwise specified in the Station Specific Requirements.

1. National Water Level Observation Network (NWLON), PORTS®, and tsunami stations.
2. Long term operating secondary water level stations.
3. New tertiary survey, COASTAL stations, and special project stations.
4. Historical subordinate water level stations with an accepted MLLW value on the current official tidal datum epoch

Static GPS surveys shall be conducted at water level stations periodically over time to establish a history of relationship between the tidal or water level datums, and the ellipsoid.

3.2.4. Criteria for Bench Mark Selection for GPS Observations

The GPS Water Level Station Bench Mark (GPSBM) shall be selected based on the following criteria: (a) permanence or stability; (b) historic GPS use; (c) satellite visibility; and (d) safety and convenience.

(a) Permanence or Stability of Bench Marks

NGS has defined the following monumentation quality codes, also called the stability codes, for various bench mark settings.

Stability code A – monuments of the most reliable nature which may be expected to hold their elevations very well; e.g. Class A rod marks, or marks installed on large boulders/rock outcrop.

Stability code B – monuments which probably hold their elevations well; e.g. Class B rod marks, or marks installed on large concrete footings/foundations.

Stability code C – monuments which may hold their elevations but which are commonly subject to surface ground movements; e.g. pavement or concrete monuments.

Stability code D – movements of questionable or unknown reliability.

The station bench mark selected for GPS observations shall be of stability code A or B. GPS observations on the PBM are preferred if the PBM is either stability code A or B, and is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations, unless NGS has previously made GPS observations on those marks.

(b) Historic GPS Use

In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. Some tidal marks designated as Federal Base Network (FBN) or Cooperative Base Network (CBN) marks may be of stability code C. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. If leveling reveals instability of the mark over time, select another mark.

Priority shall be given to a GBM for GPS observations because the GBM already has a NSRS height (NAVD 88). The GBM considered here is one of the 10 tidal or water level bench marks at a NWLON water level station, or one of the 5 bench marks for survey or special projects.

(c) Satellite Visibility

The most desirable bench mark for GPS observations should have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have these clearances, if at all possible. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new 3-D rod mark shall be established. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. A note shall be made, either in the APP field of the electronic leveling HA file or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark. The GPS visibility obstruction diagram as shown in Figure 5 under Section 6 GPS Project Documentation shall also be completed for each mark observed.

(d) Safety and Convenience

The location of the GPS bench mark should be safe, secure, and convenient. Bench mark locations which allow unattended GPS data collection are desirable as the field crew can multi-task at the same time as collecting the GPS data. The safety of the GPS equipment (vandalism proof) should be considered in the mark selection process.

The bench mark selected for GPS observations should be located on public property rather than on private property, as permissions from private owners may be required in the future to access the bench mark and for collecting the GPS data. The distance from the station DCP should also be convenient.

3.2.5. Planning, Position, and Photograph of the GPS Bench Mark

Regarding suitability of a mark for GPS observations, a review should be made first of the historical bench mark information in the station files and level records, if access to that information via database is available, or if the information is available. Stable marks from the level records are identified and copies of the descriptions and sketches are made. Descriptions and sketches are examined and marks are eliminated that have obvious obstructions, such as vertical marks, marks set several meters from medium to large structures, etc. Do not eliminate marks that are near poles, fences or about 20 meters from small structures at this time during the preliminary planning. If no other mark is available or found suitable, and time does not permit the installation of a new (GPS) mark, it may be necessary to use one of these marks. In selecting a GPS mark, priority should be given to the NWLON PBM or an NGS, NSRS, mark with a First or Second-Order NAVD 88 height on a NGS datasheet.

If time permits, conduct a site reconnaissance survey prior to starting the GPS sessions, to select the proper mark(s) to occupy with GPS. A site survey consists of preparing an obstruction diagram for each useable mark using an inclinometer and placing a GPS unit (hand-held or better) over the bench mark to determine how many satellites can be tracked at that location. Determine the location of a suitable weather proof location, if any, for the GPS receiver. Measure the distance from the mark to this location to determine the antenna cable length required. Ideal marks should have approximately 360 degree unobstructed visibility above the 10 degree elevation mask. However, satellite geometry changes with time, so for 4-hour tracking sessions some obstructions, particularly those to the north of the mark, may not degrade the precision or accuracy of the final solution.

GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the HA files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each subordinate water level station occupied for all projects.

Digital photographs shall be taken of all station bench mark disks in accordance with Reference 5 - *Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005*". A minimum of three photos shall be taken: close-up of the disk face; waist or chest level view of disk and setting; and horizontal view of location and direction of view. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the bench mark A face photo for San Francisco water level station shall be named as 94142901 BM A face photo .jpg.

A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 7. If a digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 6. A digital photo of the stamping is preferred over rubbing of the mark.

3.2.6. Data Collection and setup

Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites.

Always collect a little bit of extra data if time and schedule permit, so that blunders or invalid data, if any, can be removed during processing still leaving required minimum number of hours of valid data for one GPS session.

It is recommended that after each session is complete, two independent downloads be done from the GPS receiver to the laptop computer, so that if one downloaded file gets corrupted, the other file may have good data. Since two downloads of the GPS observation file is a requirement, do not make copy of the downloaded file twice to the laptop instead, as both the files will have the same problem, if there exists a problem. Send both copies of digital GPS data so that one copy of the data can be forwarded to NGS and other copy will be kept for record in CO-OPS' Requirements and Development Division's Operational Engineering Team (RDD/OET).

Data should be compressed and copied to a CD-ROM, diskette, and/or zip disk, as appropriate, at the end of each GPS day for transporting data from the field to the office, or hotel as the case may be, for processing. If data are logged to a PCMCIA card (flash card) in the receiver, consult the receiver User Reference Guide about re-formatting the card prior to beginning observations.

Data should be collected during periods when the Vertical Dilution of Precision (VDOP) is less than 6 for at least 90% of each 30-minute or longer GPS observations, if VDOP maps or data are available for the site.

3.2.7. North American Datum 1983 (NAD83) GPS Tie

At each NWLON station, GPS observations shall be performed as listed in the Annual Project Instructions, Annual Station Specific Requirements, and contract documents. The frequency of repeated observations on the GPSSBM shall be determined based upon the rate of sea level rise and general stability of bench marks in the local leveling network.

The NGS OPUS is now used extensively for quick and convenient processing of the GPS raw data for a variety of applications. The position solution provided by OPUS is considered preliminary data and is not retained by NGS. Further information on using OPUS is provided later in this document.

The expected ellipsoid height accuracy for a 4 hour OPUS solution is 1.8 cm, (at the 67% confidence level), and that is desirable, practical, and achievable with the requirements as specified in reference #2, NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3.

The length of GPS observation sessions depends upon the length of time the field crew has available for GPS observations, security of the equipment, number of satellites available at a site, number of GPS receivers available for GPS observations, etc.

For all water level stations, collect a minimum of 4 hours of GPS data on the GPSBM. Extra care shall be taken to ensure that the antenna height is precisely recorded, and that the antenna setup is stable. A continuous long session (at least 4 hours long but less than 24 hours) repeated annually is preferred to two or more shorter sessions (of less than 4 hours each) repeated on the same visit, providing better data for OPUS and more independent observations.

After the data collection session is complete, two independent downloads are required from the GPS receiver to the laptop computer. If one downloaded file gets corrupted, the other file may have good data. Do not make a copy of the downloaded file, as both the files will have the same problem, if there is a problem. Follow the NGS guidelines for naming these files. Submit both copies of the digital GPS data along with the necessary documentation as specified below.

3.2.8. GPS Data Processing Using OPUS

Field parties shall use OPUS for processing the raw GPS observations. OPUS provides an easily accessible, rapid method for submitting GPS data and receiving an almost instantaneous solution response from NGS via email.

The NGS OPUS web page can be obtained at http://www.ngs.noaa.gov/OPUS/.
The following information is found on the OPUS web page but is also presented here for convenience of the reader.

OPUS allows users to submit their GPS data files to NGS, where the data will be processed to determine a position using NGS computers and software. Each data file that is submitted will be processed with respect to three CORS sites. The sites selected may not be the nearest to your site but are selected by distance, number of observations, site stability, etc. The position for your data will be reported back to you via email in both - ITRF and NAD 83 coordinates as well as Universal Transverse Mercator (UTM), U. S. National Grid (USNG) and State Plane Coordinates (SPC) northing and easting.

OPUS is completely automatic and requires only a minimal amount of information from the user, such as:

(a) The email address where you want the results sent
(b) The data file that you want to process (which you may select using the browse feature; raw or RINEX accepted)
(c) The antenna type used to collect this data file (selected from a list of calibrated GPS antennas)
(d) The height of the Antenna Reference Point (ARP) above the monument or mark that you are positioning.

Once this information is complete, you then click the Upload button to send your data to NGS.

Your results will be emailed to you, usually within a few minutes. You may upload multiple data files in a zip archive if you wish. However, be careful, the options that you choose will be applied to all of the data files in that archive (i.e. the same antenna type, ARP height will be used for all of the files in the zip file).

The following are some simple guidelines for analyzing the OPUS solutions.

(a) Make sure the antenna type and the ARP height are correct.
(b) Review the solution statistics:
- (I) A good quality OPUS run should typically use 90% or more of your observations.
- (II) OPUS should have fixed at least 80% of the ambiguities
- (III) The overall RMS should seldom exceed 3 cm.
- (IV) The maximum peak to peak errors should be less than 2 cm for horizontal and 4 cm for vertical (This depends, of course, on the accuracy you are trying to achieve.)

NGS needs to receive orbit data from IGS in order to obtain a solution. If the data is submitted too quickly (before NGS gets the orbit data from IGS), the submitter may need to re-submit the data at a later time. For best results, submit the GPS data to OPUS at least 17 hours after the first midnight (in Greenwich Mean Time) following the time when the observations were recorded. Compare the resultant solution to the last previous solution made at the station, if available, to ensure that you do not have a blunder in the antenna setup. This will be revealed by a noticeable discrepancy in the ellipsoid height. Include a copy of the solution in the station inspection documentation package submitted to RDD/OET, as well as to NGS GPS data sets.

3.2.9. OPUS DB Preliminary information

Pending NGS support, OPUS DB will be released by NGS in the near future. This advanced version of OPUS will submit solutions directly to the NGS database for publication as part of NSRS if all required documentation is provided by the submitter. Further guidance will be provided once OPUS DB is released and this document will be updated as appropriate. Any data sets submitted to OPUS will be subsequently re-submitted by RDD/OET to OPUS DB to ensure the data is published by NGS, provided all the proper and required GPS data and documentation (as listed below under data submission section) has been submitted to CO-OPS.

Height modernization guidelines are listed at the following url:
http://www.ngs.noaa.gov/heightmod/guidelines.shtml

The Opus DB datasheet concept is fully listed at the following NGS web site:
http://www.ngs.noaa.gov/PROJECTS/draft/OPUS/OPUS-DB-concept.htm

The following tables identify the required data elements and optional data elements for OPUS DB respectively.

REQUIRED DATA ELEMENTS (15 each):

ELEMENT	RATIONALE
e-mail	For identification & correspondence.
Filename	Necessary to compute position.
Antenna	Necessary to compute position.
antenna height	Necessary to compute position.
name of submitting agency	Identifies the observer.
permanent identifier (PID)	Identifies the station.
Designation	Identifies the station.
descriptive text	Aids in station recovery.
Rod/pipe depth & units	Describes monumentation quality.
sleeve depth & units	Describes monumentation quality.
setting code & specific setting text	Describes monumentation quality.
photograph (of marker)	Aids in station recovery.

OPTIONAL DATA ELEMENTS (11 each):

ELEMENT	RATIONALE
photographs (of equipment, horizon)	Equipment photos describe antenna height and equipment used. Horizon photos aid in station recovery and could explain visibility or multipath problems.
vertical stability code	Useful for stability assessment.
magnetic property code	Aids in station recovery.
antenna s/n	Useful in identifying equipment-specific problems.
receiver	Useful in identifying equipment-specific problems.
receiver s/n	Useful in identifying equipment-specific problems.
receiver firmware	Useful in identifying firmware-specific problems.
stamping	Aids in station identification.
condition code	Useful for stability assessment.
special application codes	Identifies the station type (tidal station, Public Land Survey corner, etc.)
remarks	Allows user to record observation comments.

This information regarding the Required Data Elements and Optional Data Elements is for reference only and not required at the present time. These requirements will be active once OPUS DB is designated operational by NGS. Out of the 15 Required Data Elements, 13 are applicable to all the marks and the remaining two - rod/pipe depth & units and sleeve depth & units – are applicable only to rod marks.

3.2.10. NAVD 88 GPS Tie

The NAVD 88 GPS Tie involves simultaneous GPS observations at the GPSBM and one or more GBMs located up to 10 KM (6.26 mi) from the GPSBM. This “Height Mod” tie is deferred until such time as NGS enables user-friendly blue-booking of campaign data (OPUS projects).

4.0 GPS Project Documentation and Data Submission

The following information in addition to the results obtained from OPUS shall be submitted to CO-OPS at the end of the project (see the time frames for submission of GPS data later in Section 4.1) so that proper information can be forwarded to NGS for blue-booking purposes.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the “Data Submission to NGS Section” of NGS-58 (Reference 2) and the “Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base” (Reference 4) to become part of the NSRS.

GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - Receiver Independent Exchange Format (RINEX) data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

GPS forms in PDF format can be found at the following NGS Federal Base Network (FBN) web site:

http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm

Refer to Figures 1 through 7 for GPS projects submission checklist and sample package contents.

(a) Project report (Refer to Figure 1):
One project report per GPS project is required.

(b) Station (bench mark) description or recovery notes (Refer to Figure 2)
One per bench mark, for which GPS observations are submitted, is required.

(c) Observation log sheets (Refer to Figure 3 and 4)
One per each GPS observation session is required.

(d) Station/bench mark visibility diagrams (Refer to Figure 5)
One per each bench mark, for which GPS observations are submitted, is required.

(e) Photographs or rubbings of station (bench) marks (Refer to Figure 6 and 7)
One per each bench mark, for which GPS observations are submitted, is required.

(f) Raw GPS data

(g) Rinex GPS data

(h) OPUS results

4.1. Data Submission

All required GPS data and documentation shall be submitted to CO-OPS within 15 business days of the GPS observations or the removal of the gauge whichever is earlier.

All GPS data and documentation shall be submitted in paper format and in digital format such as CD-ROM in duplicate, so that one copy stays with CO-OPS and other copy is forwarded to NGS. For GPS data that are collected according to the contracts, there may be additional requirements for submission, please check with the appropriate Contracting Officer's Representatives.

Submit all GPS project data and documentation to:

Chief, Requirements and Development Division
CO-OPS, N/OPS1, SSMC 4
1305 East-West Highway, Station 6531
Silver Spring, MD 20910-3233
Tel: 301-713-2897

Figure 1 GPS PROJECT SUBMISSION CHECKLIST

Project Title : ____

Submitting Agency: ____

Observing Agency: ____

Receiver Type: ____

Antenna Type: ____

PACKAGE CONTENTS

( ) Project Report

( ) Station Description or Recovery notes

( ) Observations Log Sheets
Data which must be filled out: Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name

( ) Antenna height measurements

( ) Station Visibility Diagrams

( ) Photographs or Rubbings of Station Marks

( ) Raw GPS data

( ) Rinex GPS Data - See below

( ) OPUS Results

( ) Other

DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx
Where: aaaa = Alphanumeric 4-character station identifier,
ddd = Julian day of the year,
s = session, yy = year of observations,
and xxx is the receiver-dependent file extension (e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 navigation and observation files shall be named as follows.

RINEX2 Navigation File: aaaaddds.yyn
RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames for navigation and observation from station BALD 2 on session A of 12/31/06 are BALD365A.06o and BALD365A.06n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

Figure 2: Station (Bench mark) Description/ Recovery Form

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY
STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET

Country: (USA / USA) State: OR County: LINCOLN

Latitude: N 44 49 49.17802 " Longitude: W 124 03 56.23447 " Elevation: 17.0 (meter / ft)

Original Description (check one):	
☐ P	Preliminary (mark has not been set yet)
☐ D	A newly set mark
✔R	A recovered mark
Established by: (NGS / CGS / Other:)	Oregon DOT
Date:	Chief of Party (initials): ???

Recovery Description (check one):	
☐ F	Full description of a station *not* in the database
✔T	Full description of a station *in* the database
☐ M	*Partial* description of a station in the database
Recovered by: (NGS / Other:)	Oregon DOT
Date:	Chief of Party (initials): CFS

Monument Stability (check one):	
✔A	Of the most reliable nature; expected to hold well
☐ B	Will probably hold position and elevation well
☐ C	May hold well, but subject to ground movement
☐ D	Of questionable or unknown reliability

Recovery Condition (check one):	
✔G	Recovered in good condition
☐ N	Not recovered or not found
☐ P	Poor, disturbed, or mutilated
☐ X	Surface mark known destroyed

Setting Information:	
Marker Type: (Rod / Disk / Other)	
Setting Type: (Bedrock / Concrete / Other:)	
✔ / N / ?	Monument contains magnetic material?

Stamping:	BALD 2 1991
Agency Inscription: (NGS / CGS / Other:)	Oregon DOT
Rod Depth: (meter/ft), Sleeve Depth:	(meter/ft)
Monument is: (flush / projecting / recessed)	(cm/inch)

Special Type (check all applicable):	
☐ F	Fault monitoring site
☐ T	Tidal Station
✔--	Control Station: (FBN / CBN / Bench mark)
☐ --	Airport Control Station: (PACS / SACS)
✔/N	Mark is suitable for GPS use?

Transportation (check one):	
✔C	Car
☐ P	Light truck (pickup, carry-all, etc.)
☐ X	Four-Wheel Drive Vehicle
☐ __	Other (SnowCat, Plane, Boat; describe)
✔/N	Pack Time (hike) to mark? (hh:mm): 00:03

See Back of Form to add Text Description

General Station Location: The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Pack northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: John Q. Surveyor Phone: (301)713-3194 e-mail: jqs@ordot.gov

Figure 3: GPS Station Observation Log

--> Click here to clear the sample data <--

GPS STATION OBSERVATION LOG (01-Nov-2000)

Station Designation: BALD 2 RESET (check applicable: FBN / CBN / PAC / SAC / BM)		Station PID, if any: QE2736	Date (UTC): 31-Dec-98
General Location: Boiler Bay Wayside	Airport ID, if any: ---	Station 4-Character ID: BALD	Day of Year: 365
Project Name: Sample GPS, 1998	Project Number: GPS- 1234	Station Serial # (SSN):	Session ID:(A,B,C etc) A

NAD83 Latitude: 44 49 49.17802	NAD83 Longitude: 124 03 56.23447	NAD83 Ellipsoidal Height: -6.44 meters	Agency Full Name: Oregon DOT
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30	Epoch Interval= 15 Seconds	NAVD88 Orthometric Ht. 17.0 meters	Operator Full Name: John Q. Surveyor
Actual Start 11:55 Stop 17:32	Elevation Mask = 10 Degrees	GEOID99 Geoid Height -23.52 meters	Phone #: ( ) (301) 713-3194
			e-mail address: jqs@ordot.gov

GPS Receiver:
Manufacturer & Model: Leica SR530
P/N: p/n 667122
S/N: s/n 0030354
Firmware Version: Version 3.0
✔ CamCorder Battery, ▯ 12V DC, ▯ 110V AC, ▯ Other

GPS Antenna:
Manufacturer & Model: Trimble Choke Ring
P/N: p/n 29659-00
S/N: s/n 02200-63591
Cable Length, meters: 30 meters
Vehicle is Parked 25 meters N (direction) from antenna.

Antenna plumb before session?	✔(Y / N)	Circle
Antenna plumb after session?	✔(Y / N)	Yes or No
Antenna oriented to true North?	✔(Y / N)	-If no,
Weather observed at antenna ht.	✔(Y / N)	explain
Antenna ground plane used?	✔(Y / N)	"
Antenna radome used?	(Y / N)✔	If yes,
Eccentric occupation (>0.5 mm)?	(Y / N)✔	describe.
Any obstructions above 10º?	(Y / N)✔	Use
Radio interference source nearby	(Y / N)✔	Vis. form

Tripod or Ant. Mount: Check one: ✔ Fixed-Height Tripod, ▯ Slip-Leg Tripod, ▯ Fixed Mount
Manufacturer & Model: SECO
P/N: none.
S/N: 97-G
Last Calibration date: 1998-11-01

Tribrach: Check one: ✔ None, ▯ Wild GDF 22, ▯ Topcon, ▯ Other (describe)
Last Calibration date:

** ANTENNA HEIGHT ** (see back of form for measurement illustration)	Before Session Begins: measure and record both Meters	AND Feet	After Session Ends: measure and record both Meters	AND Feet
A= Datum point to Top of Tripod (Tripod Height)	2.000		2.000	
B=Additional offset to ARP if any (Tribrach/Spacer)	-0.003		-0.003	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				

Note: Meters = Feet X (0.3048)
Height Entered Into Receiver = 2.000 Meters.
Please note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer:
Manufacturer & Model:
P/N: pretel altiplus A2 none.
S/N: J.Q.S.
Last Calibration or check Date: 11-Sep-01

Psychrometer:
Manufacturer & Model: Psychrodyne
S/N: J.Q.S.

Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar	Weather Codes *
Before	12:00	74.0		68.0		74	29.4		00000
Middle	14:45	77.0		72.5		81	29.6		00001
After	17:30	82.5		78.0		82	29.7		00102
Average of Readings				Calculate					* See back of form for codes

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

1. Winds, calm at start, gradually increased to 20 knots by end of session.

2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment.

3. Center pole of tripod projected 3 mm into dimple of disk.
Antenna height was therefore 2 m - 3 mm = 1.997 m

Note: Entries are Required in all Unshaded areas.

Data File Name(s): BALD365A.dat
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ✔ Attached ▯ Submitted earlier
Visibility Obstruction Form: ✔ Attached ▯ Submitted earlier
Photographs of Station: ✔ Attached ▯ Submitted earlier
Pencil Rubbing of Mark: ✔ Attached

LOG CHECKED BY: JGE

Figure 4: GPS Antenna Height Measurements

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length **(A)** and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) **(B)**

$$\textit{Antenna.Height} = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm= inch x (2.54)	Overall average, cm			

S = ________________ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

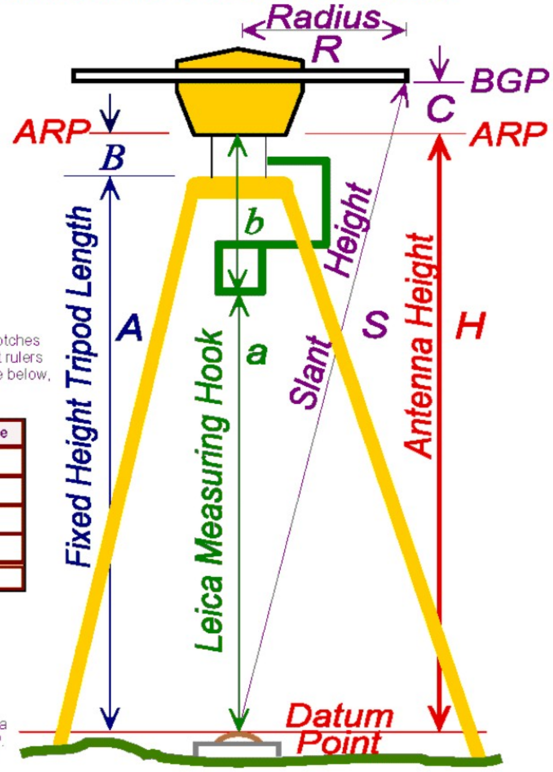
R = 19.05 cm

C = 3.50 cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$\textit{Antenna.Height} = H = ((\sqrt{S^2 - R^2}) - C)$$



III. Instructions for using the Leica Brand Measuring Hook:

Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

$$\textit{Antenna.Height} = H = a + b$$

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	**PROBLEM**	**VISIBILITY**	**TEMPERATURE**	**CLOUD COVER**	**WIND**
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80°F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80°F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over15mph (24km/h)
Examples: Code 00000 = Code 12121 =	0 - No problems, 1 - Problems,	0 - good visibility, 2 - poor visibility,	0 - normal temperature, 1 - hot temperature,	0 - clear sky, 2 - overcast,	0 - calm wind 1 - moderate wind

Figure 5: Visibility Obstruction Diagram

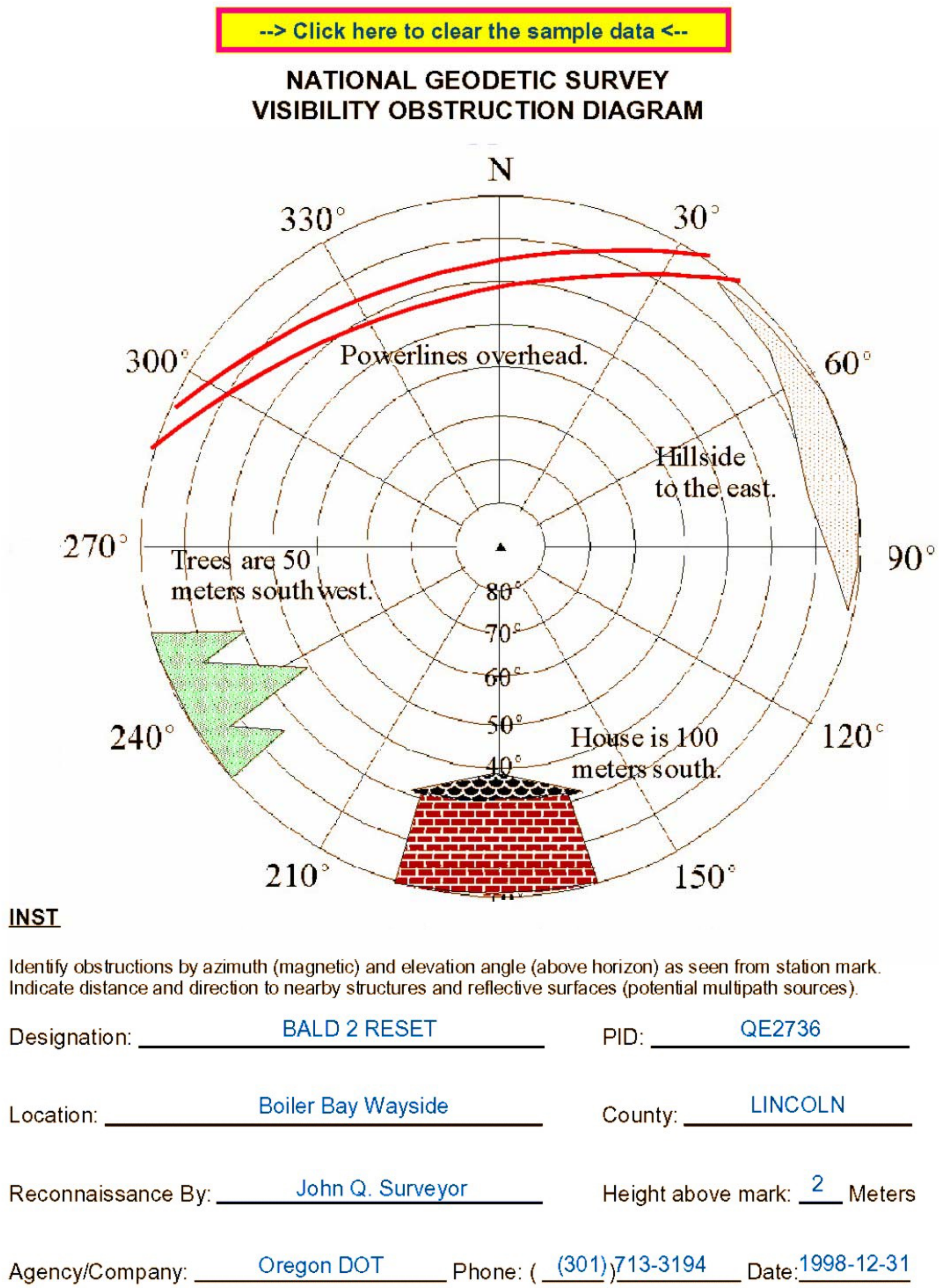
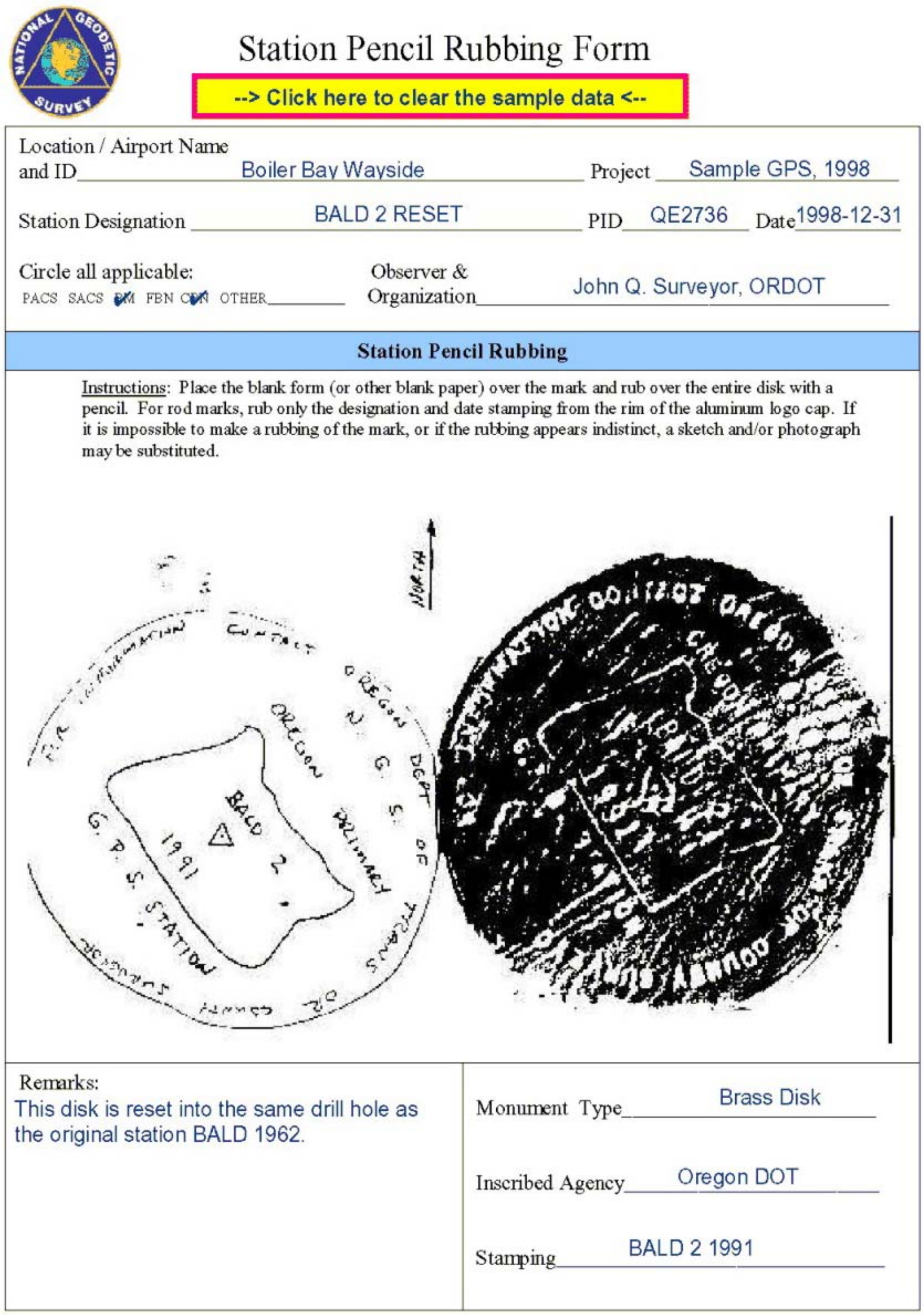


Figure 6: Station Pencil Rubbing Form



Station Pencil Rubbing Form

--> Click here to clear the sample data <--

Location / Airport Name and ID: Boiler Bay Wayside

Project: Sample GPS, 1998

Station Designation: BALD 2 RESET

PID: QE2736

Date: 1998-12-31

Circle all applicable: PACS SACS BM FBN CBN OTHER

Observer & Organization: John Q. Surveyor, ORDOT

Station Pencil Rubbing

Instructions: Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.

Remarks:
This disk is reset into the same drill hole as the original station BALD 1962.

Monument Type: Brass Disk

Inscribed Agency: Oregon DOT

Stamping: BALD 2 1991

Figure 7: Digital Photograph of a Stamping of a Bench Mark

Standing Project Instructions
for Coastal and Great Lakes Water Level Stations

Updated August 2011

Engineering Division
Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration

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Table of Contents

NOTICE

1 INTRODUCTION

The National Oceanic & Atmospheric Administration (NOAA) is a bureau of the U.S. Department of Commerce (DOC). The NOAA mission is to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs. NOAA's vision in supporting this mission is that of an informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions.

The Center for Operational Oceanographic Products and Services (CO-OPS) of the National Ocean Service (NOS) is an organizational element of NOAA. We operate and maintain a network of 210 long-term water level measurement stations as part of the National Water Level Observation Network (NWLON) around the coastal United States and the Great Lakes. The NWLON supports the following four NOAA Mission Goals:

- Healthy Oceans
- Climate Adaptation and Mitigation
- Weather Ready Nation
- Resilient Coastal Communities and Economies

CO-OPS also installs and operates short-term water level stations in support of programs such as:

- Hydrographic and Photogrammetric Surveys
- Marine Boundary Determinations
- Treaty Regulation
- Harbor Dredging
- Climate Change
- Long-Term Sea Level Rise
- Habitat Restoration
- Real Time Navigation
- NOS VDatum Program

The data collected and the products derived from these water level stations are used to:

- Ensure safe, efficient, and environmentally sound maritime commerce.
- Provide data and products required by the National Weather Service to meet storm surge flood and tsunami warning responsibilities.
- Enhance navigation through a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U.S. harbors.

PORTS® is a partnering effort based on the collaboration between NOS and local maritime communities to identify and satisfy user needs for improving the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® comes in different sizes and configurations, each designed to meet local user requirements. PORTS® includes sensors, hardware, and associated communications systems which allow the centralized, real-time data acquisition and dissemination of water levels, currents, and other oceanographic and meteorological data. The modular design of each PORTS® installation allows the straight forward integration of additional sensors to meet user requirements.

In carrying out our mission, CO-OPS performs the following:

- Establishes the standards for the acquisition and processing of water level and current data.
- Collects and documents user requirements that serve as the foundation for all resulting program activities.
- Designs new and improved oceanographic observing systems; develops software to improve data processing capabilities.
- Maintains and operates oceanographic observing systems; performs operational data analysis and quality control.
- Produces and disseminates oceanographic products.
- Archives the resulting oceanographic data.

These Standing Project Instructions provide the recurring requirements for installation, operation, maintenance, and removal of water level stations in support of the NWLON, PORTS®, Coastal Oceanographic Applications and Services of Tides and Lakes (COASTAL) Program, hydrographic and photogrammetric survey operations, NOS VDatum and reimbursable special projects. These stations provide critical data to support the following activities:

- Ensure safe navigation
- Determine flow rates to support International treaties
- Determine tidal datums for the National Nautical Charting Program and the National Shoreline Mapping Program
- Determine the baseline from which marine boundaries are delineated
- National Weather Service tsunami and storm surge warning programs
- Coastal resource restoration and management
- Long term sea level trend analyses.

The objective of these Standing Project Instructions is to ensure that all the deployed systems and sensors are maintained in an effective and consistent manner for collecting continuous, reliable, and defect-free data.

1.1 General Data and Reference Datum Requirements

The NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the latest NOAA National Tidal Datum Epoch (NTDE) of 1983-2001. The NOAA shoreline reference datums are MLLW and Mean High Water (MHW). See http://tidesandcurrents.noaa.gov/publications/glossary2.pdf for descriptions of all tidal datums. All tidal datum computations and water level reductions for shoreline surveys shall be referenced to these datums.

In cases where historical sites are re-occupied, every effort shall be made to collect the new data series on the historical Station Datum (SD). In that case, data can be acquired relative to MLLW for immediate application during the survey. If the historical datum cannot be recovered, an arbitrary SD shall be assigned to the Primary Bench Mark (PBM) and the MLLW datum calculated after 30 to 60 days of water level data are collected.

In non-tidal areas, including the Great Lakes, special low water datums have been defined and are used as chart datum in these locations. For the Great Lakes, a unique Low Water Datum (LWD) for each lake based on the International Great Lakes Datum of 1985 (IGLD 85) is the reference datum. In other non-tidal coastal areas, LWD is determined by subtracting 0.5 ft from the Mean Water Level (MWL), as calculated from the water level data collected in these locations.

Leveling and GPS connections to geodetic datums are made at each water level station, as described in Section 3.6 Geodetic connections.

1.2 Reference Documents

The following reference documents are referred in various sections of the Standing Project Instructions.

(1) "*NGWLMS Site Design, Preparation, and Installation Manual (NGWLMS Manual), January 1991*".

(2) "Xpert DCP User's Manual, October 2006". (Latest updated version)

(3) "*User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987*".

(4) "*User's Guide For Electronic Levels with Translev and Windesc, Updated September 2010*".

(5) "User's Guide for Writing Bench Mark Descriptions, Updated January 2011".

(6) "*User's Guide for GPS Observations at Tide and Water Level Station Bench Marks, Updated December 2009*".

(7) "*CO-OPS GPS Observations Implementation Plan, January 2003*".

(8) "*CO-OPS Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations, November 2008*".

(9) "Barometer Calibration Guidelines, Updated November 2008".

(10) "*Sutron Accubar Barometer Field calibration Procedures, Updated February 2008*".

(11) "*Wind Sensor Alignment Procedure for the R. M. Young Wind Sensors, October 2005*".

(12) "*Guidelines for Meteorological Sensors Siting and Meteorological Sensors Height Measurements, Updated January 2011*".

(13) "*CO-OPS Water level and Meteorological Site Reconnaissance Procedures, Updated May 2009*".

(14) "*User's Guide for 8200 Acoustic Gauge (Installation and Operation), Updated August 1998*".

(15) "*User's Guide for 8200 Bubbler Gauge (Installation and Operation), updated February 1998*".

(16) "NGWLMS GOES MESSAGE FORMATTING, Phil Libraro January 2003".

(17) "*Standards and Specifications for Geodetic Control Networks", Federal Geodetic Control Committee, September 1984*".

(18) "*Spatial Data Modifications and Enhancements, FY05 Functional Requirements Document, August 2005*".

(19) "Revised NGS 3 – Dimensional (3 – D) Rod Mark, National Geodetic Survey, July 1996".

(20) "NWLON/DMS Quality Control Software (QC): Functional Requirements Document".

(21) "NOS *Hydrographic Surveys Specifications and Deliverables, April 2011*".

(22) "*Water Level Station Specifications and Deliverables for Shoreline Mapping Projects, Updated May 2009*".

(23) "*Attachment R, Requirements for Digital Photographs of Survey Control, NGS, January 2008*".

(24) "SOP-06-001 for Upgrading or Installing a New Water Level Station, Updated August 2007".

(25) "SOP-06-004 CO-OPS Evaluation Criteria for Water Level Station Documentation, Updated October 2009".

(26) "Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP".

(27) "*E-Site Report Application User's Guide", December 29 2009*.

(28) "SOP 3.2.3.5 E(15) E-Site Report User Access to Build, Submit, Reject, Advance, and Approve Steps".

(29) "Engineering Bulletin 07-007 Downloading (Exporting) Data from Xpert Log Files using Xterm" October 15, 2007.

(30) "Engineering Bulletin 08-001 Standardization of Xpert Log File Sizes" February 13, 2008.

(31) "Engineering Bulletin 09-003 Update to Xpert Log File Sizes" November 13, 2009.

(32) "SOP-3.2.3.5 E8 Procedures for Requesting GOES Platform ID Allocations, November 14, 2007

2 REQUIREMENTS FOR RECONNAISSANCE, INSTALLATION, OPERATION, MAINTENANCE, AND REMOVAL OF WATER LEVEL STATIONS

The following sections point to the references strategic to the reconnaissance, installation, operation, maintenance, and removal of water level and/or meteorological stations.

The term Installer has been defined as a person or field party that performs any of the following tasks: reconnaissance, installation, maintenance, repair, or removal of a water level station. The installer could be CO-OPS personnel, NOAA ship personnel, Office of Coast Survey (OCS) Navigational Response Teams (NRT), other NOAA personnel, or contractors.

2.1 Reconnaissance

The reconnaissance of water level and meteorological stations shall be performed in accordance with Reference 13.

2.2 Water Level Sensor Specifications

The following sections provide the sensors and specifications that are used at CO-OPS water level stations.

2.2.1 Primary Water Level Sensor

The primary sensor used at a CO-OPS water level station is one of the following:

- Aquatrak™ self-calibrating air acoustic sensor
- Paroscientific pressure sensors tied into a single or dual orifice gas purged bubbler system
- BEI Motion Systems absolute shaft angle encoder (SAE)
- Design Analysis Waterlog microwave in a limited capacity

Currently, the Aquatrak™ sensor is used at the majority of tidal water level stations as the primary water level sensor. At stations where the acoustic sensor cannot be used due to the freezing of the water's surface or the lack of a suitable support structure, a single or dual Paroscientific intelligent pressure sensor(s) is incorporated into a gas purged bubbler system. In the Great Lakes, a sump with a float driven absolute shaft angle encoder is used. A microwave air gap sensor is used in selected PORTS® projects. Starting this year, a microwave sensor will be used in a limited capacity at low wave energy locations.

The sensor type will be determined after the reconnaissance of the site is completed, the final station design is performed, and CO-OPS has approved the site and the type of sensors. CO-OPS' approval of the type of water level sensor is mandatory for a project.

The sensor measurement range shall be greater than the expected range of water level and the installation shall be designed to measure the full range of extreme water level such as highest observed and lowest observed water level data (100 years, if available). The highest observed may have an additional wave allowance value added as determined by ED.

Sensors are calibrated prior to deployment, and the calibration is checked following removal. The calibration standard's accuracy is traceable to the National Institute of Standards and Technology (NIST).

For NWLON water level data, the water level sensor resolution is 1 mm or better. For hydrographic and photogrammetry surveys the required water level sensor resolution is a function of the tidal range of the area in which water level data is collected: when the tidal range is less than or equal to 5 m, the required water level sensor resolution is 1 mm or better; when the tidal range is between 5 m and 10 m, the required water level sensor resolution is 3 mm or better; and when the tidal range is greater than 10 m, the required water level sensor resolution is 5 mm or better.

Known error sources for each sensor are handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types. At a number of NWLON stations, dual orifice gas purged orifices which are mounted a fixed vertical distance apart and connected to two vented Paroscientific pressure transducers are used so that a density correction can be estimated for each sample based on the pressure difference and gravity.

The orientation of the primary sensor shall be carefully documented in elevation (side) view sketches and photographs, as required. Orientation of the protective well (or sump and intake in the Great Lakes) relative to the wave or current modifiers such as nearby pilings, bulkheads, or other structures in the water shall be photographed and documented. All features in the vicinity of the protective well such as, pilings, other wells, decking, buildings (tide house), etc., which might cause uneven sun/shading of the well and resulting non-uniformity of temperature inside the well shall also be well photographed and documented.

The installer shall have all forms and figures submitted using metric units and referenced to the SD as applicable. Other references (e.g. orifice zero or tide staff zero) shall also be shown on the forms with reference to the SD.

2.2.2 Redundant Water Level Sensor

The redundant sensor used at a CO-OPS water level station is one of the following:

- IMO, Druck, or KPSI pressure sensor tied into a single gas purged bubbler system
- Waterlog relative shaft angle encoder (SAE)

At tidal water level stations, the redundant water level bubbler orifices shall be secured structurally independent of the primary water level sensors (i.e. on a separate piling, etc). At Great Lakes stations, the Waterlog shaft angle encoder (SAE) shall be set to read the same as the Electric Tape Gauge (ETG) and the primary SAE.

The cable lengths of all water level and ancillary sensors shall be noted in the E-Site Report, or Xpert Site Report, or Tide Station Report to the nearest tenth of a meter (rounded up to the nearest meter value). This will assist with the efficient replacement of cables should a failure occur.

2.2.3 Tsunami Data Requirements

NWLON and other water level stations installed and supporting the NOAA Tsunami Program shall have 1 minute averaged water level data available in addition to the 6 minute data. The 1 minute averaged data will be mainly coming from the primary sensor during the normal operations. In addition, 15 second data from the redundant sensor shall also be made available in the event of a tsunami, or as per the request of National Weather Service (NWS) Tsunami Warning Centers, and the Pacific Marine Environmental Laboratory of NOAA's Office of Atmospheric Research (OAR).

The RAM pack and other storage devices may be appropriate for storing the 15 second data. The sizes of the data files (minimum number of days data) for 6-minute water level data (ssp.log), 1 minute tsunami data (tsu1min.log), and system log data shall be collected according to Engineering Bulletin 09-003 dated November 13, 2009. This Bulletin is available on the ROS Wiki Page and can be made available for contractors on request, if applicable.

2.3 Data Collection Platform

The primary Data Collection Platform (DCP) shall acquire and store water level measurements every 6 minutes. The water level measurements shall consist of an average of three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples and outliers which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data and the standard deviation provide valuable data quality information regarding each measurement.

For NWLON stations, a redundant DCP shall also be installed so that in case of a failure of a primary DCP or sensor, water level data from the redundant DCP or sensor can be retrieved. The redundant DCP also shall acquire and store water level measurements every 6- minutes and the water level measurements shall consist of an average of three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.).

The primary and redundant DCP, where applicable, shall have a capacity to store at least 30 days of 6 minute water level data and meteorological sensor data, if applicable.

2.4 GOES Satellite Transmissions

The ability to monitor water level measurement system performance for near real-time quality assurance is essential for operations. Water level data transmitted via satellite in NOS format is retrieved and monitored by CO-OPS, and in the case of data gaps, sensor, or gauge problems, corrective actions are taken immediately. At all sites where access to the GOES satellite is available, and according to CO-OPS policy, the measurement system shall be equipped with a GOES transmitter to telemeter the data to NOS. This section is applicable where water level gauges are installed by CO-OPS or CO-OPS' contractors for NWLON, Tsunami, COASTAL, VDatum, Special projects, and NOAA in-house survey projects. This section is not applicable for NOAA contract hydrographic or photogrammetric projects.

The data transmissions shall use the message format detailed in Reference 16. This format is currently implemented in the Next Generation Water Level Measurement Systems (NGWLMS), assuring compatibility with the CO-OPS Data Management System (DMS).

The NOS Continuous Operational Real-Time Monitoring System (CORMS) is a 24 x 7 data monitoring operation. It monitors all water level measurement system data transmitted via GOES to assure the gauges are operating properly. Data that is not transmitted by GOES but is submitted to CO-OPS via diskette, CD-ROM, or such other electronic media, must also conform to the format specified in the above document so that data can be loaded properly into DMS.

The clock accuracy of a satellite radio system shall be adjusted with a GPS clock for NWLON gauges. For a tide gauge that does not have a GPS clock, or that transmits hourly or three hourly, the clock accuracy of a satellite radio system shall be within 5 seconds per month for short term water level gauges so that adjacent satellite channel overlapping does not occur. Non-satellite radio systems shall have a clock accuracy of better than one minute per month.

2.5 Data Transmission Initiation and Station Database Configuration Requirements

The CO-OPS' Engineering Division (ED) Operational Engineering Team (OET) maintains the GOES platform ID list for all water level stations in the NWLON. For new NWLON stations, once the location, type of sensors, and DCP are selected, OET assigns the platform ID and provides the satellite configuration data for the deployment.

For other types of water level stations, such as subordinate stations installed for NOAA in-house hydrographic or photogrammetric surveys, or meteorological (met) only stations, OET also assigns platform IDs, as appropriate. This section pertains to water level stations installed by NOAA ships, CO-OPS, or CO-OPS IDIQ contractors. This section is not applicable for contract hydrographic and photogrammetry stations installed by OCS and NGS survey contractors.

OET will provide station numbers and platform ID assignments for equipment setup and testing when the location, which consists of a local name, body of water, and latitude and longitude, of the station is reported to OET. OET can be reached by telephone at 301-713-2897, fax: 301-713-

4465 or 301-713-4435, or e-mail address at nos.coops.oetteam@noaa.gov. Requests for GOES platform IDs shall be submitted to OET at least 15 days before throughput testing to allow sufficient time to receive radio frequency assignments. Refer to Reference 32 for procedures on requesting a platform ID.

Critical Information required for water level station database configuration at CO-OPS Database Management System (DMS):

(1) Station Number and Name
(2) Installation Date
(3) Latitude/longitude
(4) Platform ID, transmit time, channel
(5) Serial numbers of all DCPs, and sensors.
(6) Level abstract
(7) Sensor offset C1 (SNS) and Datum Offset C2 (DAT) as entered in the DCP for acoustic sensor; and orifice offset(s) for pressure sensors.

Prior to the installation of a station and initiation of GOES data transmissions from the field, critical information that is needed for database configuration shall be emailed or faxed to OET. See the figure at left for the critical information required for station database configuration in the CO-OPS DMS. Test transmissions monitored by the installer during the field unit installation may be conducted outside this requirement.

This station information must be configured in DMS for data to be accepted in DMS. Whenever possible, within 24 hours after reporting the above basic information and before the complete inspection package is submitted, the draft E-Site Report (or Xpert Site Report or Tide Station Report) shall be forwarded to OET. This is called the one-day draft E-Site Report submission requirement and its purpose is to:

1) Standardize the requirements for all of CO-OPS' field efforts;
2) Provide feedback by OET to the Installer while at the site, so that critical information is verified; and
3) Insure that timely corrective actions and required maintenance actions as described in the station specific Project Instructions can be accomplished by the Installer while at the site.

Generally, OET will respond back to the Installer or provide feedback within 24 hours or earlier during normal business hours during the work week. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular scheduled maintenance, emergency maintenance and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 27 and 28 for the User's Guide and the SOP for using the E-Site report.

The effective starting date of all operational sensor data series is the date and time when the data is first received after the DMS configuration. It is the responsibility of the installer to ensure that the required documentation is provided to OET prior to the date when the operational sensor data are needed.

For the installation of the primary sensor, a leveling connection shall be made between the Primary Bench Mark (PBM) and the sensor zero for the purpose of determining the sensor zero height with respect to the SD. For the acoustic sensor, the sensor zero is the Aquatrak™ Leveling Point (AQLP), which is the top edge of the collar on which the Aquatrak sensor rests. On the ETG, the sensor zero is the ETG reading reference mark, also known as the ZETG, Zero of Electric Tape Gauge. The Paroscientific pressure sensor zero is the vertex of the V-notch in the side of the orifice, or the bottom of the top parallel plate. To make a leveling connection to this sensor zero, a rod stop called the orifice staff stop - that can be leveled as part of the leveling run - is installed at a point above the sensor zero and a calibrated steel tape measurement is made between the sensor zero and the orifice staff stop. Using the height obtained for sensor zero with respect to the SD, the datum offset (also known as Coefficient C2 or DAT), or the orifice offset shall be calculated.

The field crew shall then submit the E-Site report, Xpert site report, or Tide Station report via email or fax. Include a copy of the level abstract (and water level transfer form for Great Lakes stations) to OET in addition to a phone call to OET so that sensor parameters can be properly setup in DMS prior to the beginning of the accepted data collection.

The Installer shall contact OET (contact information is provided above at the beginning of the section) and CORMS at telephone 301-713-2540, fax 301-713-4392, or e-mail corms@noaa.gov

a) Before performing any maintenance at a station
b) After the maintenance is completed
c) When a station is installed
d) When a station is removed.

The above procedure must be followed. If this procedure is not followed in timely fashion prior to beginning of data transmission, data losses may occur. When the station sensors are properly configured in DMS, the data is accessible through the CO-OPS' web site at http://tidesandcurrents.noaa.gov.

Changes to the satellite platform ID, or the DCP telephone number, shall be reported to OET and the supporting Field Operations Division (FOD) office immediately via telephone, email, or fax.

The Installer/tester shall follow the appropriate throughput testing requirements as described in Reference 24.

2.6 Station Installation

The installation of water level station DCPs and sensors shall be accomplished according to Reference 1, Reference 2, and the manufacturer's instructions, as applicable. Nearly all of the NWLON stations have the Sutron Xpert System (Xpert DCP and Xpert Dark as redundant DCP) installed as of February 2011.

All new station installations, excepting short-term hydro/photo stations, shall undergo an engineering design review in accordance with Section 3 of the ROS. FOD and NWLON O&M contractor engineering design packages for station upgrades and installations shall be reviewed and approved by the CO-OPS Field Engineering Review Subcommittee before any work actually begins on the site. The installer shall obtain all required permits and permissions using CO-OPS approved agreement templates for the installation of the water level sensor(s), DCPs, bench marks, and utilities, as required and provide copies of signed agreements, permits, and permissions to ED and the supporting FOD office as part of the design review process. A complete reconnaissance report and station design heights shall also be submitted. The installer shall be responsible for security and/or protective measures, as required, for protecting the government furnished equipment and facility while installing, maintaining or removing a water level station.

The water level station and its various components (tide house, Data Collection Platform, all sensors, meteorological tower, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed or installed by contractors, shall be installed and maintained as prescribed by manufacturers installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Technical Representative (COTR), if applicable. The water level station and all installed components shall be structurally sound for its intended application, secure, and safe to use for NOS, local partners, and general public, as appropriate.

The installer must provide CO-OPS with the GPS position, as noted below in Section 2.9, of all tide gauges and sensors installed before data collection begins, including those that were not specified in the Statement of Work. In cases where gauge location(s) needs to be different than that specified in the Statement of Work, installer shall consult with CO-OPS prior to the installation.

Digital photographs of water level station components (station, DCP, sensors, well, supporting structure, equipment, and bench marks) shall be taken and submitted. GPS photos shall be taken according to Reference 6.

A minimum of four photos for each bench mark shall be taken: close-up of the disk face; chest or waist level view of disk and setting; and horizontal views of the location of the bench mark from two different (perpendicular) cardinal directions. Photos shall also be taken of station components such as protective wells, staffs, houses, shelters, met towers, DCPs, sensors, etc. One general location photo shall be taken showing the water level station in relationship to its supporting structure and the local body of water. All digital photographs shall be submitted in JPEG format. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the acoustic sensor photo for DCP1 at Los Angeles shall be named as 94106601 sensor A1.jpg.

The station components and bench mark photographs are required when a new station is installed. The bench mark photographs shall be updated whenever any changes are noticed, such as damaged bench mark disk, or changes to settings, etc, or as requested in the station specific requirements.

All digital station bench mark photo files should be named such that the name of the file will indicate the station number, dash, PID number (if available), dash, stamping or designation, dash, photo type, dash, date, dot.jpg. For a new mark, the PID is not applicable as it is unavailable. A close-up photo showing the face and stamping of the bench mark is photo type 1, an eye level photo showing the bench mark and its setting is photo type 2, and a horizontal view of the bench mark showing nearby landmarks is photo type 3. For photo type 3 include the cardinal direction (N, NE, S, SE, etc) that the camera is pointing. If more than one type of photo is taken for a given view, then re-name them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use the designation instead of the stamping for the naming of the file. Use a maximum of 30 alpha numeric characters to the left of the dot. If you are exceeding 30 alpha numeric characters in the name, then truncate the stamping or designation so that the maximum number of characters in the name are 30 (including spaces and hyphens). For example, the bench mark E close-up photo for the Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

Sample file names for photo files:

Disk face photo of a new bench mark without a PID	9414290-4290A2008-1-20090101.jpg
Eye level view photo of an existing bench mark with a PID	9410660-DY2512-BM N-2-20090101.jpg
North direction photo of an existing bench mark without a PID	9447130-7130E1990-3N-20090101.jpg

In addition, place a caption on each photograph, indicating the stamping or designation of the mark, the PID, the photo type with cardinal direction, and the date of photograph taken. The Windesc program for electronic leveling has a function to assist with the photo caption.

The above naming convention for the bench mark photo files shall be applicable for all of CO-OPS' work and OCS hydrographic surveys. For NGS Shoreline mapping projects, contractors shall follow the NGS specifications for file naming of bench mark photos.

NGS Coastal Mapping Surveys require a slightly different file naming convention as described in Attachment R of the NGS Specs which is located at http://www.ngs.noaa.gov/ContractingOpportunities/SOW_Main_Text_V13B_new.pdf . All photos collected for NGS Coastal Mapping Surveys for both contract and in-house projects shall be named according to NGS convention.

A completed water level measurement station installation consists of the following:

e) The installation of the water level measurement system (water level sensor(s), primary and redundant DCP as appropriate, satellite transmitter, ancillary sensors if applicable, other equipment as necessary and its supporting structure, and a staff (if required), as specified in the Annual Station Specific Requirements, or as specified in the contract documents.

f) The recovery and/or installation of the required minimum number of bench marks and a level connection between the bench marks, Primary Bench Mark (PBM), and the water level sensor(s), or tide staff as appropriate. The minimum number of bench marks or specific marks to be leveled will be specified in the Annual Station Specific Requirements, contract documents, or as specified in Reference 3 (See section 3.3 Levels for additional leveling requirements).

g) The collection of GPS observations, a minimum four hour session, on one bench mark, and submission of the data through OPUS DB for publishing.

h) Validation by CO-OPS of complete data transmissions, and proper data ingestion into DMS, as evidenced by the data display on the CO-OPS website.

i) The preparation of all documentation and data and submission to CO-OPS (ED and supporting FOD field office) in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).

The installer shall follow the appropriate sections of the SOP-06-001 as referenced in the Reference 24.

2.7 Station Maintenance Requirements

Water level station standard annual maintenance shall be accomplished in accordance with the Appendix F of Reference 1, and the most recent version of the AI checklist, or as instructed by the Contracting Officer's Representative (COR), or by the Task Manager (TM). A PDF file or digitally scanned copy of the completed AI checklist shall be submitted for each station annual inspection. The specific maintenance requirements for each water level station will be specified in the Annual Station Specific Requirements for individual task orders for contracts.

CO-OPS shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for degraded or invalid data, when the data is disseminated via GOES telemetry using the NOS satellite message format. This includes data from CO-OPS NWLON stations, and stations supporting hydrographic and photogrammetric surveys where CO-OPS or CO-OPS contractors, Navigational Response Teams (NRT), or NOAA Ships install the subordinate water level gauges. CO-OPS shall not monitor the subordinate stations installed for NOAA contract hydrographic/photogrammetric survey projects by NOAA contractors.

This monitoring can be performed by accessing the CO-OPS web page (http://tidesandcurrents.noaa.gov). The data over the web are typically available for review within one to four hours after the configuration of the DCP and sensors in DMS during the normal business hours, after the installations of the DCPs and sensors in the field, and once data is reviewed and dissemination is turned on by CORMS.

During annual maintenance visits to a station that has an acoustic sensor, the Aquatrak™ sensor and matching cal tube shall be replaced. For stations where wind sensors are installed, wind sensor nose cones shall be replaced during the annual maintenance. The Ultrasonic wind sensor leads (if in question) shall be cleaned with a contact cleaner with a zero residue base. All applicable sensor serial numbers (inside the tide or gauge house) shall be verified by the installer (recorded by one person and confirmed by a second person in the field party). Safety of personnel is of utmost importance and safety gear as necessary shall be used while climbing the towers, etc, when required. Most of the serial numbers of the DCP boards and sensors are generally recorded and verified during the installation, and only when equipment is replaced during the maintenance, then the re-verification of the serial numbers is required.
Necessary repairs or alterations to the stations and equipment shall be made and documented on the approved E-Site Report, Xpert Site Report, or Tide Station Report.

Repairs or alterations required by the Standing Project Instructions or the Annual Station Specific Requirements, but not completed, shall be documented, along with the reasons for the incompletion, on the approved E-Site Report, Xpert Site Report, or Tide Station Report. Each field party crew chief shall provide a draft E-Site report, Xpert Site Report, or Tide Station Report wherever possible, within one day of completion of maintenance and leveling operations to OET.

The report(s) shall be completed by the installer before leaving each station; and reviewed by the field team leader or contractor supervisor after completion of the maintenance visit but prior to submission. The reviewed station package shall then be submitted to ED and the supporting FOD field office within 1 month after the completion of the maintenance, or as specified in the contract documents.

A minimum of 30 days of 6 minute water level data and 15 days of 1 minute tsunami water level data shall be downloaded during each maintenance trip for NWLON stations and the data shall be forwarded to OET as described in Section 4.2.2 Documentation Requirements. Engineering Bulletin # 07-007 “Downloading (Exporting) Data from the Xpert Log Files using Xterm” provides information regarding how to download the data from Xpert DCP.

Sizes of the Xpert Log Files (ssp.log, tsu1min.log, and System.log) shall be configured according to the Engineering Bulletin 09-003 “Update to Xpert Log File Sizes”.

Approved primer and anti-fouling paint shall be used on all new protective wells and all protective fiberglass/PVC components that will be in water, excluding the acoustic sensor calibration/sounding tube.

For dual orifice pressure sensor configurations, the vertical stability and elevation to the leveling points from each orifice shall be verified, including the distance between the two orifices. To do so measure the elevation of each orifice to the staff-stop using a steel tape graduated in millimeters. Two independent readings shall be taken and they should not vary more than 3 mm, then report the average of the two readings. If the two readings vary more than 3 mm, then take additional readings until two readings are obtained within 3 mm. The mounting assembly for the two orifices shall be checked for structural integrity and the orifices shall be cleaned of biofouling.

When first arriving at a station to perform annual maintenance, check and record the voltage for each battery on all DCP units. Then remove AC power to both the Primary and Redundant systems allowing them to run totally on battery power**.** After the units have had approximately an hour of transmit loads on the Xpert DCP and at least 2 hours for the 9000 DCP, recheck the voltage. If the battery voltage has dropped significantly (i.e. below 11.7 volts), replace it. Also write the date of installation with permanent marker on each battery, and record this date on the site report. Check all marine grade batteries to ensure that adequate water is in each cell. Use only distilled water for replacement.

A new battery shall be replaced every four years during the maintenance trip for the NWLON stations, where practical, or make arrangements to replace it at another time. The condition of a newly installed battery shall be checked using the procedure described in the above paragraph during the 2nd or 3rd year maintenance trip, and if the battery condition passes the test described above then replace the battery during the 4th year after the installation. Of course, if a battery does not pass the condition test as described above, then it shall be replaced immediately during that trip and the date of replacement shall be duly noted on the approved E-Site Report (or Xpert Site Report or Tide Station Report, if applicable).

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate approved maintenance forms (refer to Section 5 for requirements for deliverables for water level station documentation and timelines) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time (GMT) of the beginning and the end of the maintenance activity; date and time of adjustments of the sensors; changes in the configuration of the DCP - such as a new datum or sensor offset, or setting the time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed and test results; etc.

Proper NOAA identification emblems with an emergency phone number 1 (800)367-6622 shall be placed on all water level gauge house doors or shelters. Emblems which are unreadable should be replaced.

A completed station visit for maintenance (scheduled or emergency) consists of the following:

a) The maintenance or repair of the water level measurement system (water level sensor(s), primary and redundant DCP as appropriate, satellite transmitter, ancillary sensors if applicable, other equipment as necessary and its supporting structure, and a staff if applicable), and as specified here in the Standing Project Instructions, the Annual Station Specific Requirements, or as specified in the contract documents.

b) For scheduled maintenance, the recovery and/or installation of the required minimum number of bench marks and a level connection between the bench marks, PBM, and the water level sensor(s), or tide staff is required. The minimum number of bench marks or specific marks to be leveled will be specified in the Annual Station Specific Requirements, contract documents, or as specified in Reference 3 (See Section 3.3 Levels for additional leveling requirements.)

   For emergency maintenance, recovery of bench marks and levels are generally not required, unless the maintenance is done which may affect the elevation of the AQLP, or orifice(s) for pressure sensor(s), in which case leveling, to the PBM and at least 2 other marks, is required.

   Only for scheduled maintenance, GPS observations on one of the bench marks as specified in the Annual Station Specific Requirements, or as specified in the contract documents, may be required.

c) CO-OPS verification of complete data transmission throughput following maintenance, from station to DMS ingestion.

d) The preparation and submission of all documentation and data to ED and the supporting FOD field office in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).

The maintenance party shall follow the appropriate sections of the SOP-06-001 as referenced in the Reference 24.

2.7.1 Additional Requirements for NOAA Sentinels

NOAA Sentinels are water level observing stations which have been strengthened to deliver real-time storm tide data during severe coastal events. Elevated atop substantial single pile platforms, these stations are specifically designed to withstand category four hurricanes. NOAA Sentinels measure and disseminate real-time water level and meteorological observations. All of this information helps coastal authorities prepare for, mitigate, and respond to storm tides generated by severe coastal storms.

The following are the additional maintenance requirements for the NOAA Sentinel stations currently installed in the Gulf of Mexico:

Every Year:

- Examine the anode and the anode attachment points. Inspect the attachment points for excess corrosion and inability to remove fasteners. Provide measurements of the smallest cross sectional area of the anode. Provide underwater photos of the anode and close-ups of any excessive anode shrinkage or attachment point corrosion.

Every 2 years:

- Inspect all painted surfaces for rust. Document significant rust areas in the Excel or E-Site station report and provide photos of the occurrences. The repair of significant rust areas shall be added to the following year's project instructions along with procedures for coating repair.

- Inspect all galvanized surfaces for rust. Document significant rust areas in the Excel or E-Site station report and provide photos of the occurrences. Repair spot rust with a wire brush and cold galvanizing.

- Inspect all welds for rust and cracks. Provide photos and document excessive rust and cracks.

- Check all fasteners on the protective well clamps, including half moon clamps, adjustable arms, and attachment to clamp brackets. Tighten if loose.

- Check the fasteners holding the solar panel mount to the railing. Tighten if loose.

- Check all fasteners holding the enclosure to the support stand and the stand to the deck grating. Also check the bracketing system along the upper portion of the enclosure. Tighten if loose.

- Check all fasteners on the Rohn tower. Tighten if loose.

- Examine the underside of the high platform. Inspect the high platform bridge bolts for looseness and rust. Document and tighten any loose bolts.

- Examine the galvanized conduit for rust and cracks. Check also for water in the conduit entering the bottom of the enclosure.

- Examine the solar panel and Rohn tower flexible conduits for cracks and loose fitting/tubing connections.

- Grease the davit and winch. Examine for corrosion.

Every 5 Years:

- Replace the battery pack in the Aid to Navigation light

2.7.2 Additional Requirements for Great Lakes Stations

- The shaft angle encoders shall be inspected to insure the offset pulleys are not binding. Lift the float tape off of the offset pulley and free spin the unit. If any binding occurs, replace the bearing in the center of the gear. In addition and while the float tape is off of the encoder gear and pulley, spin the encoder shaft to represent both a 2 meter increase and a 2 meter decrease in the readings from the present reading. Then match the reading with the ETG reference and reset the tape back on the gear and pulley. After this process, remember to check the tape at the float connection to ensure that it has not kinked. This rotation procedure will ensure that the oil lubrication around the enclosed encoder bearings remains fluid. NOTE: - This test should only be performed during the time period that the DCP is not calculating the water level reading. This time period, for computing the water level reading, is 90 seconds before and after the allotted 6 minute interval. Also check to see that the float tape length has been installed such that the float neither tops out nor the counterweight bottom out before reaching its extreme limitations.

- The float shall be inspected for corrosion and leaks; replace as necessary.

- When closing off the intake valve note how many turns it takes to close off the intake as well as how many turns it takes to fully open it. This shall be reported in the remarks on the inspection sheet and on a tag placed on the valve handle. Also note the difficulty in turning the valve such that it can be predicted when the valve would become unusable and need replacement.

- A water level transfer (inside/outside check) shall be performed at each station and documented on the Site Report. The inside/outside water level must agree to within 0.006 m. The best time to perform a transfer is in the early morning or late evening when the water level is most calm. The above procedure must be followed and actions taken to correct any discrepancies.

- When diving at gauge sites measure and report the elevation of intake invert and valve invert on IGLD 85, if not previously noted. NOTE: The invert elevation is the point where the water level can no longer be measured accurately. If the intake has a gooseneck at the end this measurement should be taken at the lowest point in the curve at the top of the gooseneck, not the opening.

- Install rubber flaps over all locks on gauge shelters for protection against the weather. The locks shall be inspected and lubricated to enable easy access.

- Check gauge houses inside, outside, and around the doorframe for openings in the mortar and caulk as required. Submit a statement of work to FOD for any work recommended for completion by a contractor.

- Check gauge house structure, door, and frame for rust and paint chips. Scrape and paint as necessary.

2.8 Ancillary Sensor Metadata

The meteorological sensor site selection and measurement guidelines are listed in Reference 12.

Specific metadata for ancillary sensors is required as detailed below. The installer shall make note of this data in the remarks section of the Ancillary Sensor boxes on the approved Site Report or E-Site report. Metadata documentation shall be completed during the annual inspections, or emergency maintenance visits, as appropriate, for all stations with ancillary sensors. A unique Temporary Bench Mark (TBM) may be selected at each station and all the required measurements can be referenced to that TBM. The TBM must be connected via levels to the PBM. Then ED will relate the sensor elevations to SD and other datums as appropriate.

Photos shall be taken of the supporting structure and all of the ancillary sensors installed. The photos should include as many of the four cardinal compass directions as possible, with the file name indicating the direction of the view, i.e. 87617241 Met tower looking south.jpg. Photos and sensor elevations must be submitted by CO-OPS to the National Data Buoy Center (NDBC) in a timely manner before NDBC will accept the met data into its quality control process. Annual photos of the met mast and ancillary sensors are not required once the sensors have been installed. Wind sensors shall be aligned according to Reference 11.

Ancillary Sensor	Sensor Elevation Reference Point
Air temperature	Center of the sensor above the station datum and above ground to the nearest +/- 15 centimeter.
Water temperature	Center of the sensor above the station datum as derived from subtracting the distance from the leveling point to the center of the sensor from the C2 value, to the nearest centimeter.
Barometric pressure	Surface of the pressure port above MSL (see Barometer Calibration Guidelines) to the nearest +/- 15 centimeter.
Wind Speed/Direction/Gust	Center of the sensor above the station datum and above ground to the nearest +/- 15 centimeter. Note any major physical obstructions in the vicinity of the sensor.
Conductivity	Center of the loop above the station datum to the nearest centimeter.
Relative humidity	Center of the sensor above the station datum and above the pier/ground surface to the nearest centimeter.

Air gap	Sensor zero above the station datum as determined from trigonometric levels to the nearest centimeter.

2.9 Obtaining and Recording Positions of Stations, DCP, Sensors, and Bench Marks Using a Hand-Held GPS Receiver

Latitude and longitude of the station, DCP, all sensors, and bench marks shall be recorded using a hand-held GPS receiver and recorded as degrees, minutes, seconds, and tenth of seconds (e.g. 45 degrees, 34 minutes, 32.6 seconds). The positions of the primary and backup DCP and all sensors that are installed in a tide house (gauge house) shall be recorded as that of a station. This position will be obtained in front of the tide house (gauge house) at the center of the front door/front wall of the tide house (gauge house). The front portion of the roof of the tide house (gauge house) may also be used as applicable if the GPS satellites are blocked from the structure. For a standalone DCP or met sensors that are 3 m (10 ft) or greater from the station, obtain positions and report appropriately on the Site Report.

For barometers which are generally installed in the tide house, report the latitude and longitude as that of the station, but report the elevation above station datum as obtained from the leveling.

For Aquatrak sensors or Paroscientific sensors that are installed 3 m (10 ft) or greater from the station location, obtain the positions of the sensors at the center of the sensor. If the Aquatrak sensor or Paroscientific sensor is installed inside a tide house (gauge house), then report the latitude and longitude as that of the station, but report the elevation above station datum.

For bench marks, obtain positions using the hand-held GPS receiver by placing the receiver on the (horizontal) bench mark. For bench marks that are installed vertically, obtain the position as close to the mark as satellite coverage will allow.

Handheld GPS units come with either patch antennas or quadrifilar antennas. The proper method for holding the GPS unit is vertically if the unit has a quadrifilar antenna, or horizontally if the unit has a patch antenna. Holding the unit otherwise will degrade the reception of the satellite signals and reduce the accuracy of the position obtained. The Garmin GPSmap 76S units used by CO-OPS have quadrifilar antennas.

Take a digital photo of the GPS unit display for each location acquired. This will insure verification of the latitude and longitude that is entered into the Excel and E-Site reports.

2.10 Gauge Removal

The installer shall remove a water level station, if required, and as specified in the Annual Station Specific Requirements, or as specified in the contract documents. A complete removal of the water level measurement station consists of the following:

a) Closing levels - a level connection between the PBM and all the bench marks in the local leveling network at the station, the water level sensor(s), and/or staff, if applicable.

b) Removal of the water level measurement system and restoration of the premises, assuming reasonable wear and tear. The property owner shall be notified prior to removal and thanked for supporting our programs.

c) Generally, GPS observations on one bench mark are done during the installation for short term stations. If GPS observations are not done during the installation phase, and GPS observations are required, then GPS observations shall be done during the gauge removal time. Generally, GPS observations are required only one time for short term stations. For NWLON and long term stations, the frequency of the GPS observations is determined by the rate of sea level change at the station and if the GPS observations are required for a specific year, those will be listed in the station specific project instructions.

d) The preparation of all documentation and data and submission to CO-OPS (ED and supporting FOD field office) in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).

e) Return of all government equipment to appropriate supporting CO-OPS' FOD field office(s) in timely fashion within 15 days of station removal.

3 BENCH MARKS AND LEVELS

3.1 Reference Documents

Bench marks and level operations shall be performed in accordance with Reference 3.
CO-OPS electronic/barcode level operations shall be performed in accordance with Reference 31 and the Leica Manual for the DNA03 level. Help files for the TOPCON and Trimble level instruments can be found in the Windesc and Translev programs available from NGS.

Bench mark descriptions shall be written in accordance with Appendix E of Reference 4 for bench marks that are connected using the electronic levels. Descriptions for Great Lakes bench marks shall be written in accordance with the NGS Bluebook, Formats and Specifications of the National Geodetic Survey Data Base http://www.ngs.noaa.gov/FGCS/BlueBook/, since those marks are not published by CO-OPS.

Bench mark descriptions shall be written in accordance with Reference 5 for bench marks that are connected using the optical levels, where electronic levels are not used, or as specified in the contract documents.

3.2 Bench Marks

Unless specified otherwise in the work order or contract documents, the total number of bench marks in the leveling network shall be a minimum of ten marks for the NWLON stations and a minimum of five marks for subordinate stations installed for hydrographic and photogrammetry surveys, special projects, or contract projects for U. S. Army Corps of Engineers, unless otherwise directed by ED.

Descriptions shall be checked by verifying distances with tape measurements in metric units, verifying cited landmarks and using a compass to confirm directions.

The handheld GPS coordinates of each mark shall be entered in the description file for electronic levels, or noted on the published bench mark sheet or equivalent (for optical levels). The latitude and longitude fields of the bench mark shall be reported in the following format: degrees/minutes/seconds and tenths of seconds. For example, 40 degrees, 45 minutes, 35.2 seconds.

New bench mark sketches shall use CO-OPS' standard bench mark sketch title block, or electronic equivalent. If a digital sketch is used, submit the digital file in JPG format with the leveling files and photos. If AutoCAD or AutoCAD LT is used to generate the benchmark sketch, both a JPG format and the AutoCAD DWG format shall be submitted. Submission of updated bench mark sketches are required only when necessary to document newly established marks or physical changes in the area.

CO-OPS has photos of nearly all bench mark disk faces, setting, and location shots of NWLON and active subordinate station tidal bench marks. The station specific requirements shall note any additional photos needed to achieve a complete photo gallery of each mark.

If a bench mark is discovered disturbed or mutilated during the visit to a station, include it in the level run to determine if it is holding its elevation relative to the PBM and report it to ED and the supporting FOD field office. ED will make a decision and inform the installer via the next set of Station Specific Requirements regarding the action that needs to be taken: destroying the mark, if it is a NOS mark, or dropping the mark from the leveling network for other marks. If the PBM has been disturbed, contact ED immediately for further direction.

Before installing a new mark, perform a 1.6 kilometer (1 mile) radial search from the tide station (DCP) location at NGS web site, http://www.ngs.noaa.gov/datasheet.html to check if any NAVD 88 marks are available that are not part of the local leveling network. Inclusion in the local leveling network of an existing mark(s) that has a NAVD88 elevation, if it is located within a 1.6 KM (1 mile) leveling distance of the station location, is desirable and shall be preferred over installing a new mark. If the bench mark is replaced, then the stamping of the bench mark shall have a new letter designation (assigned by ED) and present year so that the new stamping is different from the original stamping of the mark, or the stamping of other marks in the local leveling network.

Digital photographs of bench marks shall be taken as described in Section 2.7 Station Installation.

3.3 Levels

All leveling shall be performed with electronic/barcode systems, to either Second Order, Class I or Third Order standards, in accordance with National Geodetic Survey (NGS) standards for geodetic leveling, and CO-OPS "User's Guide for the Installation of Benchmarks and Leveling Requirements for Water Level Recording Stations, NOAA/NOS October 1987". Beginning in calendar year 2010, all CO-OPS and contractor field crews are required to use the NGS Windesc description and Translev leveling software. Refer to the "User's Guide for Electronic Levels with Translev and Windesc, Updated September 2010"

If digital bar-code leveling systems are to be used, the model should have been previously evaluated by the Federal Geodetic Control Subcommittee (FGCS). These systems include the Leica NA3003, Leica DNA03, Topcon DL101C, Trimble DiNi 12, Zeiss DiNi 10, DiNi 11, DiNi 12 and DiNi 12T. Bench mark descriptions and leveling output must be in a NGS-supported format to enable processing and adjustment of the levels by NGS. Station bench mark descriptions and recovery notes shall be submitted in computer-readable form using WinDesc software. The basic WinDesc usage instructions are built into the program. You simply go under the HELP menu when you run WinDesc. Field book and field abstract software are required and are dependent on the leveling equipment used for this project. Translev is a NGS program that facilitates the process of editing, formatting and checking digital leveling observation data and creates abstracts, bok files, and VERTOBS datasets for submission to the National Geodetic Survey (NGS). WinDesc and Translev are the two programs currently being used by CO-OPS to submit leveling data to NGS. NGS training is available if needed. These NGS programs are available online at http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml.

CO-OPS will provide appropriate training to contractors in the use of the Windesc and Translev software for leveling operations,

Second-order Class I leveling connections shall be made from the primary water level sensor (AQLP or pressure sensor orifice [staff stop], and in the Great Lakes the ETG RM and the Spike RM) to a minimum of 5 bench marks on an annual basis, including the primary bench mark (PBM). In the case of pressure sensors as primary sensors, the elevation of orifice zero to orifice staff stop(s) shall be measured annually using a calibrated steel tape with millimeter graduations, and elevation of the orifice staff stop(s) to PBM shall be determined using the conventional leveling equipment.

As described in the "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987" Section 3.3, Page 18, the levels are required and shall be performed for seven cases listed. Particular emphasis is placed on performing the check levels as per the specific project requirements or no later than 6 months after the establishment of a new water level station. This is required for declaring a newly installed water level station operational.

All of the bench marks in the leveling scheme shall be leveled within a two year period. This may be accomplished by leveling to the PBM and four marks one year, then to the PBM and the remaining marks the next year. In some cases, it may be practical to level to all the marks the second year to reach the furthest marks from the station. A level connection to CORS reference marks shall also be made once every two years, if those marks are within 1.6 KM (1 mile) leveling distance from the water level station. The installer shall be responsible for ensuring that every mark in the station bench mark network is leveled once every two years.

The two or three meter barcode rods for second order levels shall be used whenever possible at all stations. At stations where three/two meter level rods cannot be utilized due to airline size restrictions, justification for use of the Third Order barcode rods and levels shall be documented on the NGWLMS Site Report. For stations in AK, HI, and Pacific Island areas the Second order class I leveling requirement is waived and the Third Order levels are acceptable.

The primary water level sensor (ETG in the Great Lakes) shall be connected to the station bench marks by levels. The levels shall be run upon sensor installation, in conjunction with annual maintenance levels, if obvious sensor movement is noticed during regular/emergency maintenance, and upon sensor removal. The levels to the sensor(s) shall be spur runs from any bench mark, it is not necessary to have the spur run directly from the PBM to the sensor(s). If the leveling starts at the sensor then it is not considered a spur run.

At Great Lakes sites where a spike is unavailable for use in performing a water transfer, (see section 3.1, standing project instructions for a description of procedures to perform water transfers), the water level in the sump shall be compared to the water surface outside the sump by differential leveling and the use of the water level transfer program (h2o-tran). A difference exceeding 0.006 meters indicates a possible restriction in flow, which must be corrected. This instruction must be recognized and initialed. Note: this procedure can best be accomplished in early morning or late evening when the water is most likely to be calm.

When abstracting the raw level data using the electronic digital level system, the PBM shall always be selected as the starting mark, and the AQLP, orifice staff stop, or ETG, as the case may be, shall always be selected as the ending mark. If the original RAW file is edited before processing, the original file (XXXXXXXo.RAW) shall be stored in a separate subdirectory named “Original RAW”, and submitted with the edited RAW (XXXXXXX.RAW) file and other level files.

While using the electronic levels, any changes made to the description file (XXXXXXX.DES) require that the levels be reprocessed and submitted to ED. Dates of the DES file must be chronologically consistent with the abstract ABS and other files generated. The date of the DES file cannot be later than the date of the ABS file.

Newly installed barometric sensors shall be included in the level run as a spur. Barometric pressure sensors shall be leveled, or their height otherwise determined in relationship to station datum, during installation, or if the barometer is moved to a new location. Barometric sensors at Great Lakes stations shall be leveled, or their height otherwise determined in relationship to DYNAMIC/IGLD 85. Since small changes in elevation do not change the height correction, the original leveling requirement to the barometer every five years is not needed. The elevation of Mean Sea Level (MSL) above Station Datum in the header information for the specific annual requirements for each station is based upon the 1983-01 tidal datum epoch. The Barometer C2 shall be computed to include both the calibration corrections and height corrections. The installer shall ensure that the new elevation is also correct on the Site Report section for calculation of the barometer C2. The barometer C2s shall be updated in the DCPs during the annual inspections. The SSN for the barometric sensor shall be xx10 if it is included in the electronic leveling, where xx is the part number. At Great Lakes stations, the “Barometer Installation Worksheet – Great Lakes” shall be used to compute the Height of the Barometer above the ETG. Refer to Reference 9 for additional information.

3.3.1 Leveling to NOAA Sentinels and Elevated Platforms

Leveling connections on Sentinels and other elevated platforms require a combination of steel-taped height differences between the AQLP or a TBM at deck level (“deck” TBM) and a TBM near ground level (“ground” TBM), and a standard level run between the “ground” TBM and bench mark network.

To level from the AQLP to a TBM that can be included in the standard level run a TBM shall be chosen that can be leveled to the existing bench mark network using the standard barcode rod. This “ground” TBM shall be named and described per Reference 5 so that surveyors can level to the exact same TBM in future level runs during the maintenance of the Sentinel or elevated platform. The point where the taped measurement is made is critical in this description. This TBM shall also be placed in a position where a taped measurement can be made from the TBM to the AQLP. If this is not possible, another TBM at the deck level of the Sentinel or elevated platform shall be chosen, then named and described per Reference 5, again with care to include the point of measurement in the description. This “deck” TBM shall be connected to the AQLP using standard leveling procedures.

The steel taped distance from the “ground” TBM to the AQLP or “deck” level TBM shall be performed on a windless day. A plumb bob shall be dropped from the AQLP or “deck” TBM to insure that the steel tape is held as vertical as possible. A set of five readings each shall be made by a minimum of two people for a total of ten readings. Each reading shall have the zero of the steel tape positioned at the high point of the “ground” TBM and the elevation shall be read from the tape at the AQLP or the high point of the “deck” TBM. The steel tape shall also be moved away from the TBMs and repositioned for each reading. The ten readings shall be averaged to acquire the height between the “ground” TBM and the AQLP or “deck” TBM.

The averaged steel tape height shall be entered into the DNA03 so that it is abstracted in to the level run. This is done by manually entering a zero for the staff height on the “ground” TBM as the **Backsight**, then entering the **positive** value of the averaged steel tape height for the **Foresight** of the **Forward Run**. During the **Backward Run**, enter zero for the **Backsight**, then a **negative** value of the averaged steel tape height for the **Foresight**. This will put the height of the AQLP or “deck” TBM into the abstract when the levels are processed using Translev.

3.3.2 Leveling to Temporary Bench Marks (TBM)

Due to leveling to meteorological sensors and water level sensors connected to DCPs other than DCP 1, the designation for TBMs shall be changed to include the full 8 digit station number: XXX XXXXY, where XXX XXXX is the Station ID, and Y is the DCP number. For example: If the barometer is installed on DCP 1 at 8410140 Eastport, the designation shall be TBM 841 01401 Barometer. If the barometer is installed on DCP 2, the designation shall be TBM 841 01402 Barometer. This format shall be used for all **SENSOR** TBMs

In addition, there have been several new water level TBMs added that are standardized in the following table. Use the designations below to correctly identify the orifice and microwave water level leveling point at a water level station. Due to the character limitations in WinDesc and Translev, it may be also be necessary to assign an alias.

Leveling Point (LP) Designation	**Leveling Point Alias**	**Sensor Zero Measurement Point Designation**
TBM xxx xxxxx Single Orifice LP	Single Orifice LP	Single Orifice Zero
TBM xxx xxxxx Dual Orifice LP*	Dual Orifice LP	Upper Orifice Zero
		Lower Orifice Zero
TBM xxx xxxxx Upper Orifice LP**	Upper Orifice LP	Upper Orifice Zero
TBM xxx xxxxx Lower Orifice LP**	Lower Orifice LP	Lower Orifice Zero
TBM xxx xxxxx MWWL LP	MWWL LP	N/A

*For Dual Paros installations sharing the orifice LP use the designation TBM xxx xxxxx Dual Orifice LP.

**For Dual Paros installations with separate orifice LPs for the upper and lower orifice, use the designations TBM xxx xxxxx Upper Orifice LP and TBM xxx xxxxx Lower Orifice LP.

3.4 Datum Offsets and Accepted Orifice Offset

The leveling connection to an acoustic sensor shall be done at the AQLP. The AQLP is defined as the top shoulder of the mounting plate collar on the calibration tube. In order to facilitate rod holding, a prefabricated leveling fixture may be slipped over the sounding tube to rest on the leveling point. The height of the leveling fixture, as inscribed on the fixture, shall be compensated for in the leveling record (abstract). The level abstract shall show the elevation of the leveling point only. A barcoded rule or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used in lieu of the leveling fixture by holding the rule directly on the leveling point. In cases where the leveling point is too high for a rod shot, the leveling fixture designed for a down shot shall be utilized and the readings recorded to reflect the down shot. Use of other leveling fixtures and leveling techniques must be approved in advance by ED.

The leveling connection to an ETG shall be done at the reading mark (RM). A barcoded rule (60 cm scale) or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used by holding the rule directly on the RM.

The AQLP elevation above station datum is defined as the Datum Offset and is computed by algebraically adding the PBM elevation above SD to the acoustic sensor elevation above/below the PBM. The Datum Offset is also referred to as Coefficient C2 for the Sutron 9000 DCP and as DAT coefficient for the Sutron Xpert DCP.

The orifice zero elevation for the Paroscientific pressure sensor(s) above or below the SD is defined as the Accepted Orifice Offset and is computed by algebraically adding the PBM elevation above SD to the (sensor) orifice zero elevation above/below the PBM. The orifice zero elevation is considered to be the point of the V on the brass orifice. For dual orifice systems the orifice offsets are established for both “N1” and T1” pressure sensors.

At Great Lakes stations, the Dynamic Height of the ETG RM, plus or minus the Hydraulic Corrector, at all lake stations, defines the IGLD 85 datum offset. In the Great Lakes Rivers and Connecting Channels stations the “Dynamic Height = IGLD 85”, Hydraulic Correctors are not applied. This datum offset is applied to the Primary Water Level C2 and should only be changed by ED after reviewing the abstract and Water Level Transfer.

When using the electronic/barcode leveling system, all five decimal places shall be used to determine the Datum Offset on the approved site report. After adding or subtracting the difference between the leveling point and PBM, to the elevation of the PBM above the SD, round off the five place value of the Datum Offset to four places. Rounding shall be done to the even number, for example: 1.53455 is rounded to 1.5346. A note shall be made to the effect that the existing Datum Offset was retained in the DCP, or the new Datum Offset was entered with date and GMT time it was entered. When new Datum Offset is entered into the DCP, additional notification is required as listed below under Section 3.5 Movement. For stations that have the Paroscientific pressure sensor(s) as primary sensor(s), the change of accepted orifice offsets shall be documented on the Site Report with GMT date and time, and additional notification is required as listed below under Section 3.5 Movement.

If optical leveling equipment is used, then all elevations shall be recorded to the tenth of a millimeter level (e.g. 12.3457 m) on the leveling abstract.

After documenting the dynamic elevation for the ETG and SPIKE at Great Lakes stations, round to four places and apply these elevations to the “Water Level Transfer” program. Then apply the Hydraulic Corrector utilizing the sign, negative or positive in the program. This elevation is now the hydraulically corrected reference elevation, Zero Electric Tape Gauge (ZETG) and is then rounded to three places and entered in the DCP as Primary Water Level C2. C2 will not be changed unless the elevation differs by greater than $\pm$ 0.003 meters and only then after notification and review by ED.

When setting up the encoder offset at Great Lakes stations, the C2 in the Xpert DCP (sensor 14, coefficient 2 in the 9000 DCP) will need to be zeroed (0.000). The encoder gear will then be turned to reference 6.000 M on the display. Then an ETG reading will be obtained and subtracted from the 6.000 M reference. This difference, called the initial C2, is then stored in the Xpert DCP (sensor 14 coefficient 2 in the 9000 DCP). All ETG/Display readings have to be within 0.003 m. If not, the set up procedure must be performed again. NOTE: This procedure can best be accomplished in early morning or late evening when the water is most likely to be calm or by closing off the valve.

The accepted PBM elevation above IGLD85 in meters shall be used as the starting elevation on the level abstract at Great Lakes stations. This method results in all bench mark elevations referenced directly to IGLD85.

At coastal sea level stations, the accepted PBM elevation above the SD in meters shall be used as the starting elevation on the level abstract. This method results in all bench mark elevations referenced directly to the SD. "Old" (before sensor swap) and "new" (after sensor swap) AQLP connections, if required, shall be treated as spurs. Regardless of whether the acoustic sensor head is swapped or not, the leveling shall be done only once after the sounding tube has been cleaned and everything is put in place. For stations that have acoustic sensors installed, upon initial inspection of the station, if the installer suspects a movement of the well or that of the AQLP, then leveling shall be done twice, once before disturbing the well or sounding tube for cleaning and then after repairing the well or cleaning the sounding tube. For stations that have pressure sensor(s) installed, upon initial inspection of the station, if the installer suspects a movement of the orifice(s), then leveling shall be done twice, once before disturbing the orifice(s) and then after repositioning/securing of the orifice(s).

3.5 Movement

The movement of an entity, such as (a) AQLP, (b) pressure orifice zero, or (c) bench mark is defined as change in elevation of the entity in excess of 0.0060 m (0.020 foot) as obtained by comparing the current difference in elevation of the entity with PBM, with the previous difference in elevation of the entity with PBM. For acoustic sensors this difference shall be compared to what is stored in the DCP and appropriate action shall be taken as described below. For pressure sensor orifices this difference shall be compared with the accepted orifice offset as listed on the site report (and stored in DMS) because the accepted orifice offset is not stored in the DCP and appropriate action as described below shall be taken.

The movement shall be noted in the remarks box of the leveling section of the approved site report. If the Datum Offset determined from the latest level run indicates a deviation exceeding 0.0060 meter from the value presently stored in the field unit, and the PBM has remained stable, the new Datum Offset shall be entered into the field unit (no verification levels required) after consultation with ED. If the PBM is determined to be unstable, and other bench mark differences remain within the 0.0060 m allowable, the Datum Offset in the field unit shall not be changed. The suspected movement of the PBM shall be specifically noted, as instructed above, for further action by ED. At Great Lakes stations, if the Primary Water Level Coefficient 2 (C2) determined from the latest levels indicates a deviation exceeding 0.003 meter from the value presently stored in the field unit, and the PBM has remained stable, contact ED within 24 hours and provide the leveling abstract and Water Level Transfer.

ED and the supporting FOD field office shall be notified by phone or email immediately when the Datum Offset is changed in the DCP, or the accepted orifice offset has changed more than +/- 0.0060 m. An email (nos.coops.oetteam@noaa.gov), fax copy of the level abstract (fax 301-713-4465), and a phone call (telephone 301-713-2897) if possible, must be received by ED and supporting FOD field office within 24 hours of the change. Contact information for FOD field offices are listed in Section 4.2.3.

3.6 Geodetic Connections

Water level datums are local vertical datums which may vary considerably within a geographical area. A geodetic datum is a reference surface relative to which heights are determined. The North American Vertical Datum of 1988 (NAVD 88) is the accepted vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationships of tidal datums to geodetic datums such as NAVD 88 and to ellipsoid heights (above GRS 80 ellipsoid) support many hydrographic, coastal mapping, and engineering applications including monitoring of sea level changes, the deployment of GPS Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum (VDatum) transformation tool.

Existing Geodetic Bench Marks (GBM) in the vicinity (up to 1.6 km (1 mile) leveling distance) of a water level station (primary and subordinate) shall be searched for and recovered. If a mark is either not recovered or not used in the survey/project, a separate report shall be made using the NGS on-line Mark Recovery Entry Form at http://www.ngs.noaa.gov/ngs-cgi-bin/recvy_entry_www.prl

The connection to geodetic datums involves the following three leveling ties:

1) NAVD88 Level Tie
2) NAD 83 GPS Tie
3) NAVD88 GPS Tie

An orthometric level connection and ellipsoidal GPS tie are required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

The required "NAVD 88 Level Tie" is described in this document and the required "NAD 83 GPS Tie" and "NAVD GPS Tie" are described in Reference 6.

3.6.1 NAVD 88 Level Tie

There are two parts for this requirement as described below in A and B.

(A) NAVD 88 Level Tie: At all water level stations, a valid level tie to at least two GBM is required on each set of levels, where appropriate GBM marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At many NWLON stations, the Primary Bench Mark (PBM) is a GBM. At the majority of NWLON stations, there are two or more tidal bench marks that are also GBM, thus increasing the chance that the geodetic level tie would be valid.

Make a Second-Order, Class 1 level tie to NAVD88 for all NWLON stations in the conterminous United States and Caribbean Islands. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas.

At stations supporting hydrographic or shoreline mapping surveys, or other special projects, the tie shall be consistent with the accuracy of the levels required for the project (e. g. 2nd order class 1 or 3rd order levels, etc.).

The Translev leveling program includes a check function that will tell the user if a two mark tie to NAVD88 has been successful. Information on performing a valid level tie is also provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:
http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5

Also, *Section 3.4 of "User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987"* provides the same information regarding how to perform a valid level tie. The information in User's Guide is easier to follow as it is written in layman's terms.

The Second-Order, Class 1 tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs (within a mile of station location) is required at each site.

A note shall be made in the remarks of the leveling section of the Site Report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If a successful NAVD 88 level tie is performed, then NAVD 88 elevations for all the bench marks in the local leveling network (10 for NWLON and 5 for subordinate stations) can be determined for the NOS Vertical Datum transformation (VDatum) program.

If the water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the NAVD 88 level tie requirement is waived.

(B) NAVD 88 Level connection: An orthometric level connection is required at each water level station (primary and subordinate) which has at least one GBM located within 1.6 km (1 mi) leveling distance of a water level station. If the water level station has two or more GBM within 1.6 km (1 mi) of radial distance of the station location, then perform a NAVD 88 Level Tie (as described above in A) which fulfills the requirement for NAVD 88 level connection.

A successful NAVD 88 level connection to a GBM will help determine the approximate NAVD 88 elevations for the all the bench marks in the local leveling network (10 for NWLON and 5 for subordinate stations) for the NOS VDatum program.

If there are no GBM within 1.6 km (1 mi) leveling distance of the station location, then the requirement for NAVD 88 level connection requirement is waived.

3.6.2 Leveling at CORS

For any NGS Continuously Operating Reference System (CORS) reference bench mark that is located within 1.6 km (1 mi) leveling distance of a water level station DCP, a leveling connection shall be made to the tidal bench marks in the water level station network every two years.

Information about NGS CORS stations can be obtained at http://www.ngs.noaa.gov/CORS/.

As of 2010, there are a limited number of water level stations in this category, but NGS and CO-OPS are attempting to secure funding to establish additional co-located sites to support long-term sea level trends monitoring.

3.6.3 GPS Connections

An orthometric level connection and ellipsoidal GPS tie are required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

GPS connections involve the following two ties:

1) NAD 83 GPS Tie
2) NAVD88 GPS Tie

The required “NAD 83 GPS Tie” and “NAVD GPS Tie” are described in Reference 6.

4 SCHEDULE, REPORTS, AND DELIVERABLES

4.1 Schedule and Reports

Operations schedules are prepared for all water level stations each September for the upcoming fiscal year. Schedules for FOD and contractor operations are combined to produce one composite plan for CO-OPS. Overall accomplishments are compared to the plan on a monthly basis and reported to CO-OPS management.

Contractors shall provide ED and the supporting FOD field office a proposed annual schedule for accomplishing the indicated work in the station specific annual project instructions, or task orders, at the beginning of the task order with updates on a monthly basis, or as specified in the contract documents. Changes to the schedule must be requested in advance and approved by the Contracting Officer's Representative (COR) or CO-OPS.

Operations related to the indicated work in the station specific annual project instructions, or task orders, shall be discussed in a monthly activities report, or as specified in the contract documents.

4.2 Deliverables – Timelines, Documentation, and Points of Contacts

4.2.1 Timeline Requirements

Wherever communications allow, the one-day draft E-Site Report (or Xpert Site Report or Tide Station Report) along with level abstract shall be forwarded to OET within 24 hours after the following maintenance activities:

a) Installation of a water level station;
b) Completion of regular scheduled annual maintenance;
c) Completion of emergency maintenance;
d) Completion of check levels; or
e) Removal of a water level station.

The purpose of the one-day draft E-Site Report submission requirement is to:

1) Standardize the requirements for all of CO-OPS' field efforts;
2) Provide feedback by OET to the Installer while at the site, so that critical information is verified; and
3) Insure that timely corrective actions and required maintenance actions as described in the station specific Project Instructions can be accomplished by the Installer while at the site.

Generally, OET will respond back to the Installer or provide feedback within 24 hours or earlier during normal business hours during the work week. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular scheduled maintenance, emergency maintenance and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 28 and 29 for Users Guide and SOP for use of E-Site report. The Installer shall follow the SOP for using the E-Site report as described in reference 29.

The installer is required to submit the required documentation as described below in Section 4.2.2 to CO-OPS ED and the supporting FOD field office or the Task Manager within 30 calendar days of completion of water level station installation, maintenance, repair, removal, GPS observations, or as specified in the contract documents, whichever is earlier.

All data and documentation submitted to CO-OPS shall be retained by the installer for a period of not less than three years or as stipulated in the contract, whichever is longer.

4.2.2 Documentation Requirements

The standard water level station documentation package includes the following:

1) Transmittal letter (PDF format)
2) E-Site Report, or Water Level Station Xpert Site Report, or Tide Station Report (E-Site report in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format)
3) Google map image, or NOAA Chart image showing the station location including the standard title block with NOAA chart number. (PDF format)
4) Name of the U.S. Geological Survey quadrangle map (7.5 seconds interval) indicating the exact location of the station, with map name and scale shown (PDF format)
5) Sensor test worksheet (PDF format)
6) Sensor elevation drawing (PDF format) showing sea floor, pier elevation, and sensor elevation if the sensor is mounted vertically.
7) Water level transfer form (for Great Lakes stations only - PDF format)
8) Barometer Installation Worksheet (for Great Lakes stations only - PDF format)
9) Bench mark sketch (PDF format) – Large-scale bench mark location sketch of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge.
10) Bench mark descriptions with handheld GPS coordinates (d/m/s.s format), and “Station to Reach” statement in Microsoft Word format (See Reference 5).
11) Digital photographs of each bench mark disk (four views), station, DCP, equipment, underwater components, and vicinity (JPEG format).
12) Levels (electronic files) including leveling equipment information and field notes of precise leveling, if applicable.
13) Abstract of precise leveling (electronic format).
14) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor “zero” measurement point is referenced to the bench

marks.

15) Staff to gauge observations, if applicable (Microsoft Excel format)
16) Calibration certificates for Invar leveling rods, if applicable (PDF format)
17) Calibration records for sensors, if applicable (PDF format)
18) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (PDF format)
19) Other information as appropriate, or as specified in the contract (PDF format)
20) Water level data download in specified format
21) GPS Deliverables - the OPUS published datasheet and 4 photos of the GPSBM in electronic format for each observation session as described in the User's Guide for GPS Observations at Tide and Water Level Bench Marks.
22) Annual Inspection (AI) checklist (Applicable for all CO-OPS' NWLON AI)

The station documentation shall be submitted in digital format only. All GPS data and documentation shall be published to NGS OPUS.

Water level data downloaded for NWLON, PORTS, Tsunami, COASTAL, or in-house projects shall be in accordance with Reference 26 *"Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP".* Water level data downloaded for contract hydrographic and photogrammetry survey projects and submitted to CO-OPS for validation shall be in accordance with Reference 27 *"NOS Hydrographic Surveys Specifications and Deliverables" Latest update.*

Generally, for established NWLON stations or long term water level stations (more than 1 year), the bench mark sketch, chartlet, and "To Reach" statement need only be submitted if these items have been revised during the station maintenance or removal, because these items are required and are generally submitted with the installation station package.

When using the electronic/barcode system, all digital files created using the Windesc and Translev programs shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted.

For submission in electronic format, the station documentation shall be organized by various folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media, such as DVD/CD-ROM, FTP sites, etc.

Here is an example of submission of the electronic folders for San Francisco tide station:

9414290 San Francisco 2010 Annual Inspection
/Transmittal letter
/Calibration records for sensors, if applicable
/Site Report or tide station report
/Station Chartlet
/Sensor test worksheet
/Sensor elevation drawing
/Bench mark sketch

/Bench mark descriptions and “Station to Reach” statement
/Photographs of bench marks, station, DCP, equipment, and vicinity in digital format
/Levels (raw) (electronic files) and field notes of precise leveling
/Abstract of precise leveling
/Staff to gauge observations, if applicable
/Datum offset computation worksheet or Staff/Gauge difference work sheet (elevation of sensor zero measurement point referenced to bench marks)
/Calibration certificates for Invar leveling rods, if applicable
/Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
/Other information as appropriate, or as specified in the contract
/Water level data (6-minute, hourly heights, high/low, monthly means, station datum)
/GPS deliverables, as applicable
/Diving Documents

Submit required GPS deliverables, including the OPUS published datasheet, and 4 photos of GPSBM on a separate digital media, such as DVD/CD-ROM, FTP sites, etc. For example, GPS submission for San Francisco tide station will be as follows:

9414290 San Francisco 2010 Annual Inspection
/OPUS Published Datasheet
/Photos of GPSBM

4.2.3 Points of Contact for Deliverables

All required deliverables listed in Section 4.2.2 above shall be submitted to the proper point of contact as listed in the project instructions, contract documents, if applicable; or to NGS or CO-OPS (see below) within 15 business days of the GPS observations, installation, maintenance, or a removal of a water level station, or as specified in the Statement of Work or contract, whichever is earlier. All GPS data and documentation shall be published to NGS OPUS.

(A) For all work done by NOAA (FOD, NOAA ships, NRT, other NOAA personnel) submit one copy of all the documentation including the GPS deliverable in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Chief, Engineering Division
CO-OPS, N/OPS1, SSMC 4, Station 6531
1305 East-West Highway
Silver Spring, MD 20910-3233
Tel: 301-713-2897 x 145

(B) For all CO-OPS’ IDIQ contract work deliverables, submit two copies of all the documentation including the GPS submission in digital media, such as DVD/CD-ROM, FTP sites, etc. Submit one copy in digital media to:

Marty Welch
Contracting Officer’s Representative
NOAA/NOS/CO-OPS

SSMC 4, Station # 6544
1305 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 2897 X 129

Submit the other copy of the completed station package to the Task Manager, or appropriate supporting FOD field office.

For East Coast task orders, submit to:
Task XXX Manager, Field Operations Division Atlantic Regional Office
808 Principal Court
Chesapeake, VA 23320
Tel: 757-436-0200

For West Coast task orders, submit to:
Task XXX Manager, Field Operations Division Pacific Regional Office
7600 Sand Point Way, NE
Bin C15700
Seattle, WA 98115
Tel: 206-526-6360

(C) For OCS contract hydrographic survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Chief, Engineering and Development Branch
CO-OPS, N/OPS1, SSMC 4
1305 East-West Highway, Station 6507
Silver Spring, MD 20910-3233
Tel: 301-713-2897 x 190

(D) For NGS contract shoreline mapping survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Mr. Greg Stinner
Contracting Officers Representative
NOAA/NOS/National Geodetic Survey
SSMC 3, Station # 8609
1315 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 3167

HORCON/VERCON OBSERVATION LOG

DATE: **SESSION:**

WX CONDITIONS:

OBSERVER(S):

DN:

4 CHAR. SITE ID:

SESS. FILE NAME:

ELEV. MASK: ________degrees

RECORDING INTERVAL:__________sec.s

PROJECT NAME:

SITE NAME: ___________________ **SITE PHOTO(S): Y / N**

SITE TYPE: HORZ. / VERT. / ATON / BM / NEW / _______________

RECEIVER #: _____________________ **FIXED HEIGHT? Y / N**

ANTENNA #: **SPACER? Y / N**

ANT. MEASUREMENTS		**ANT. CONSTANTS**	
ANT. SLANT HEIGHT (**S**)		ANT. RAD. (**R**)	V. OFFSET (**C**)
START	STOP		
_______ m _______ ft	________ m ________ ft	________ m	________ m

OBSERVATION TIMES AND STATUS

RECEIVER TIME (UTC)	PDOP	LOCAL TIME	# of SV's	POWER
START:				
STOP:				

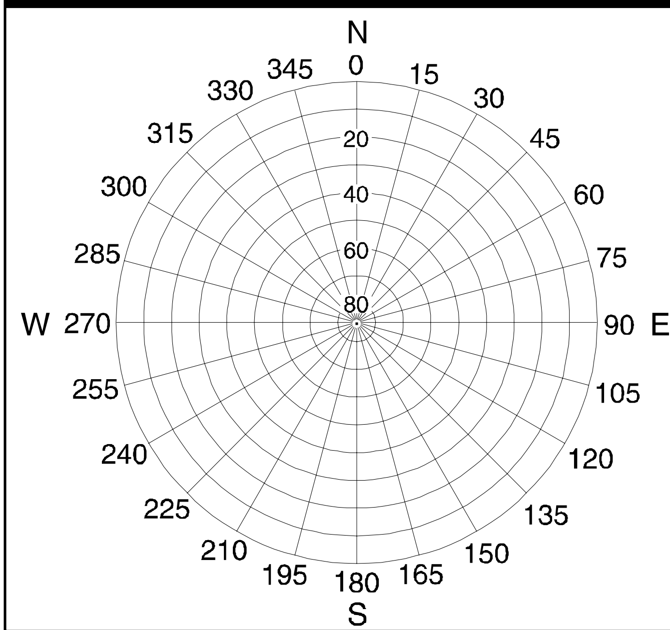
INSTRUCTIONS:

Office Check by:

HI to ARP=((SQRT(S^2-R^2) – C): **(m)**

SITE SKETCH/LOC./NOTES:

OBSTRUCTION DIAGRAM



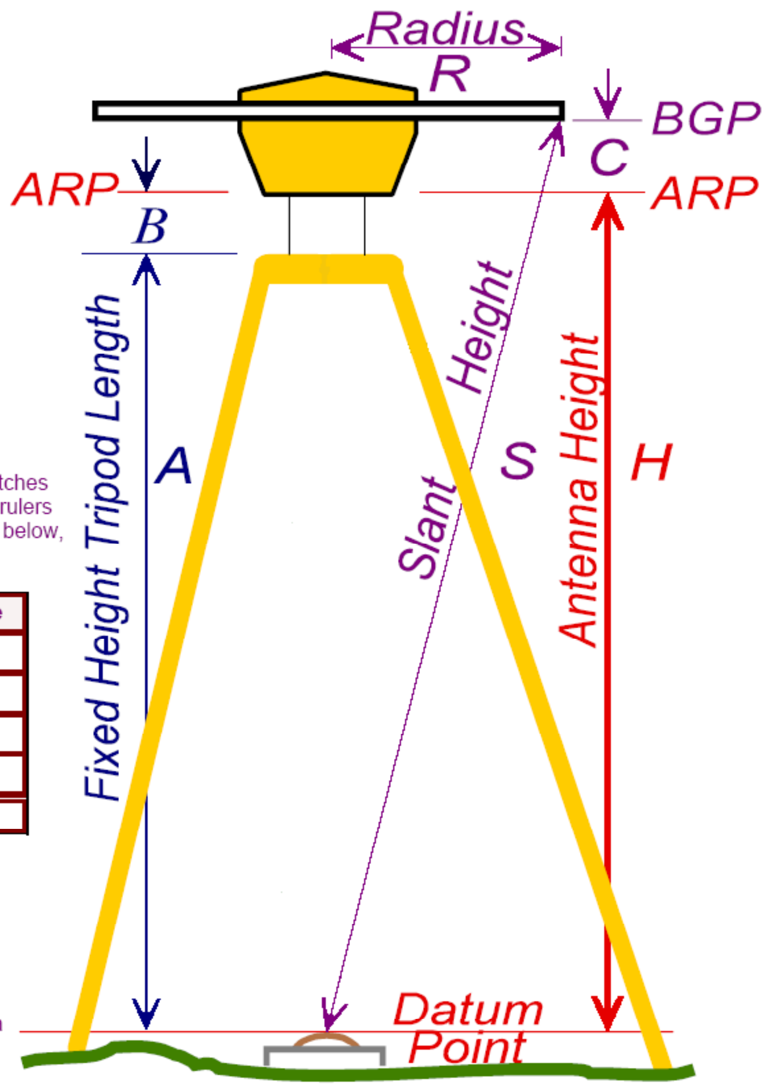
MONUMENT RUBBING / DESCRIPTION

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length **(A)** and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) **(B)**

$$Antenna.Height = H = A + B$$



II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm				
Before, inch				
After, cm				
After, inch				
Note: cm= inch x (2.54)	Overall average, cm			

S = ________________ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

R = ________________ cm

C = ________________ cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$Antenna.Height = H = ((\sqrt{S^2 - R^2}) - C)$$

NOAA Technical Memorandum NOS NGS-58

GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS
(STANDARDS: 2 CM AND 5 CM)
VERSION 4.3

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November 1997

CONTENTS

GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS
[Standards: 2 cm and 5 cm]
Version 4.3

Preface:

The following guidelines were developed by the National Geodetic Survey (NGS) for performing Global Positioning System (GPS) surveys that are intended to achieve ellipsoid height network accuracies of 5 cm at the 95 percent confidence level, as well as ellipsoid height local accuracies of 2 cm and 5 cm, also at the 95 percent confidence level. See Appendix A for information about local and relative accuracies. These guidelines were developed in a partnership with Federal, state, and local government agencies, academia, and private surveyors and are the result of processing various test data sets and having extensive discussions with various GPS users groups.

We are confident that these guidelines, if followed, will result in achieving the intended accuracy. Additional tests may show that some of these guidelines can be relaxed. These guidelines are intended for establishing geometric vertical control networks.

These guidelines will be expanded in the future to include the establishment of GPS-derived orthometric heights that approach these same accuracies, 2 cm and 5 cm. The slight differences between the accuracies of GPS-derived ellipsoid heights and GPS-derived orthometric heights will be generally due to the accuracy of the geoid model and published orthometric heights used to evaluate the differences between the three height systems, i.e., ellipsoid, geoid, and orthometric heights.

Note: these guidelines assume that for the survey project area in question, NGS has completed the establishment of a high accuracy reference network at 100-kilometer spacing or that a state-wide High Accuracy Reference Network (HARN) has been established, i.e., there are A- or B-order stations distributed throughout the state at an approximate spacing of 50 km or else there are Federal HARN stations or GPS Continuously Operating Reference Station (CORS) sites located within 75 km of the project area.

An effort should be made to connect to stations which were previously determined using these guidelines (or equivalent).

Introduction:

Accurate connections to the control stations cited in the Observations section on the next page must be made in the International Terrestrial Reference Frame (ITRF) coordinate system. (See Appendix C for more information on ITRF.) This is accomplished by simultaneous observations between selected A-order (5 mm + 1:10,000,000 accuracy standards) stations of the International GPS Service for Geodynamics (IGS) and/or NGS CORS or NGS-approved CORS within about 75 km of the project. NGS-approved CORS are those which NGS has positioned or approved with respect to the ITRF/NAD 83 coordinate systems. If there are none available, B-order (8 mm + 1:1,000,000 accuracy standards) stations within about 75 km of the project may be substituted. However, it must be noted that the use of some of the B-order stations may mean that the network accuracy of +/- 5 cm will not be achieved.

These IGS stations and CORS sites are located throughout the United States. The IGS stations or CORS sites located closest to the project must be used. The following commands are used to access the NGS CORS system:

Ftp cors.ngs.noaa.gov
login: anonymous
Password: your complete e-mail address

The same files are accessible with Web browers (i.e., Mosaic, Netscape, Internet Explorer). The NGS home page is at http://www.ngs.noaa.gov

"Information about A- and B-order stations is given on five sets of CD-ROMs covering the United States." The particular CD-ROM that covers the project area in question can be obtained by contacting NGS' Information Services Branch, 1315 East-West Highway, Silver Spring, Maryland 20910, (301) 713-3242 (voice), (301) 713-4172 (Fax). A limited amount of this information, i.e., the 100 closest stations of any type, can be retrieved from the NGS world wide web site. The electronic bulletin board system and/or web site usually contain new stations that have been added after the CD-ROM was produced.

Analysis of the quality of project data shall be based on repeatability of measurements, adjustment residuals, and analysis of loop misclosures. Please be aware that repeatability and loop misclosures do not disclose all problems.

Observations:

The following requirements are for both 2-centimeter and 5-centimeter standards, unless otherwise stated.

1. Dual-frequency, full-wavelength GPS receivers are required for base lines greater than 10 km and are the preferred type of GPS receiver for all observations, regardless of base-line distance. Geodetic-quality antennas with ground planes are required. Whenever possible, antennas used during a project should be identical; otherwise corrections must be made for antenna phase patterns. Different makes and models of antennas have different antenna phase patterns. If antenna phase patterns are not accounted for, mixing different antennas in a project can cause vertical discrepancies of as much as 10 cm. Some manufacturers are including software packages which correct for the use of different antennas. (It should be noted that choke ring antennas help reduce the effect of multipath and are highly recommended.)

The manufacturer, model, and complete serial numbers of all receivers and antennas must be included on each station Session Observation Log.

2. The survey shall be referenced to at least three existing National Spatial Reference System A- or B-order three-dimensional control stations near the project area. The survey will also consist of at least three primary base stations that are referenced to the three control stations and interspersed throughout the project. The survey will also include secondary base stations and local network stations to meet the spacing requirements in item 5., below. Primary and secondary base stations can be newly established stations in this project.

A sample project with observing scheme is depicted in figure 1 located at the end of the section. A summary of the guidelines is provided in table 1 located at the end of the vector processing section. See Appendix A for more information about control, base, and local network stations.

3. For control stations and primary base stations, receivers shall collect data continuously and simultaneously for at least three, 5-hour sessions on 3 different days during the project.

4. Observation periods for stations other than control stations and primary base stations are as follows:

a. For the 2-Centimeter Standard: Each base line (adjacent station pair) must be occupied for a minimum of 30 minutes per session.

b. For the 5-Centimeter Standard: Observations between primary and secondary base stations must be for a minimum of 30 minutes per session. While there is no minimum observation time for local network stations, each base line (adjacent station pair) must be occupied long enough in each session to ensure that all integers are fixed and the RMS for the base line solution does not exceed 1.5 cm.

5. The observing scheme is based on the GPS survey of marks spaced as indicated below for 2- and 5-centimeter standards. Stations in the scheme

are noted as either control, primary base station, secondary base station, or local network stations. (The observing scheme chosen for a sample project is depicted in figure 1, page 7.)

For the 2-Centimeter Standard: Spacing between local network stations cannot exceed 10 km; the average spacing must be less than or equal to 7 km. Spacing between primary base stations cannot exceed 40 km and spacing between primary and secondary base stations cannot exceed 15 km.

For the 5-Centimeter Standard: Spacing between local network stations cannot exceed 20 km; the average spacing must be less than or equal to 10 km. Spacing between primary base stations cannot exceed 50 km and spacing between primary and secondary base stations cannot exceed 20 km. (Note that secondary base stations may not be required in projects of small areal extent. See Item 2. above.)

6. The observing scheme for all primary base stations requires that each primary base station must be connected to at least its nearest primary base station neighbor and nearest control station according to the observing procedures stated in item 3., above. Primary base stations must be traceable back to two control stations along independent paths.

In addition to this requirement for primary base stations, the observing scheme for all base stations (primary and secondary) requires that each base station be connected with at least its two nearest primary or secondary base station neighbors according to observing procedures stated in item 4., above. For secondary base stations, one of these connections must be to its nearest primary base station neighbor. Secondary base stations must be traceable back to two primary base stations along independent paths.

Local network stations must be traceable back to two base stations along independent paths.

The observing scheme for all stations requires that all adjacent stations (base lines) be observed at least twice on 2 different days and at two different times of the day according to observing procedures shown in item 4. on the previous page. The purpose is to ensure different atmospheric conditions (different days) and significantly different satellite geometry (different times) for the two base line measurements.

Observations on the second day should be completed between 27 and 33 hours after the completion of the first day's observations if the first day's observations were begun prior to 12:00 noon. Or, the observations should be completed between 15 and 21 hours after the completion of the first day's observations if the first day's observations were begun after 12:00 noon. This is necessary since the satellite constellation geometry repeats itself every 12 hours.

Examples:	First-day observations Begun during:	Second-day observations Completed anytime between:
	8:00 a.m. to 8:30 a.m.	11:30 a.m. and 5:30 p.m.
	10:30 a.m. to 11:00 a.m.	2:00 p.m. and 8:00 p.m.
	1:00 p.m. to 1:30 p.m.	4:30 a.m. and 10:00 a.m.
	3:30 p.m. to 4:00 p.m.	7:00 a.m. and 12:30 p.m.

(Note that the second day of observations does not need to follow immediately after the first day. Satellite geometry moves ahead, or precesses, 4 minutes per day. If the second observations are not performed within 1 week of the first, this daily 4-minute change must be accounted for when meeting the different satellite geometry requirement.)

7. Selection of primary and secondary base stations in order of most-to-least- preferred are: 1. High Precision Geodetic Network (HPGN)/HARN (either Federal Base Network (FBN) or Cooperative Base Network (CBN) stations which have level ties to bench marks of A- or B-stability quality during this project; 2. bench marks of A- or B-stability quality or HPGN/HARN stations which were previously tied to bench marks of A- or B-stability quality; 3. User Densification Network (UDN)stations which have level ties made during this project; or 4. bench marks of C stability quality. In areas of known or suspected subsidence or uplift, special guidelines may need to be followed.

8. Data should be collected during periods when the Vertical Dilution of Precision (VDOP) is less than 6 for at least 90 percent of each 30-minute, or longer, observing period. For shorter observing periods, as in some projects where the 5-centimeter standard is the goal, a VDOP greater than 6 should be avoided entirely. Travel between stations could be scheduled during large VDOP periods.

9. For sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. For sessions less than 30 minutes, collect data at 5-second intervals.

10. Track satellites down to at least a 10-degree elevation angle. (Note that tracking below 15 degrees may be helpful during processing when collecting data for less than 30 minutes.)

11. If possible, coordinate observations with local, existing CORS which are collecting phase data with dual-frequency receivers.

12. Meteorological data must be collected at the control stations and primary and secondary base stations. Weather data consist of wet- and dry-bulb temperatures (or dry-bulb temperature and relative humidity) and atmospheric pressure. For sessions greater than 2 hours, record weather data at the beginning, middle, and end of each session. For sessions that are less than 2 hours in length, but more than 30 minutes, record weather data at the beginning and end of each session. For sessions that are less than 30 minutes in length, collect data at the mid-point of the session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and also immediately before it passes, if possible. Atmospheric pressure measurements must be made at approximately the same height as the GPS antenna phase center. Record on the observing log the time and where the weather data were gathered, and any abnormal weather conditions.

(Note that even though all of these data may not used in the vector processing, they may be helpful during the analysis of the results and in future reprocessing with more robust software.)

Before taking weather observations, the meteorological instruments should be allowed ample time (approximately 10 minutes) to stabilize to ambient conditions. Observations of wet- and dry-bulb temperatures must be observed and recorded to at least the nearest 1 degree Celsius. Barometric readings must be observed and recorded to at least the nearest 1 millibar. Meteorological data should be collected at or near the antenna phase center. All equipment must be checked for proper calibration.

13. Antenna set-up is critical to the success of the project. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. Plumbing bubbles must be shaded for at least 3 minutes before checking and/or re-plumbing. The perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

For the 2-Centimeter Standard: Fixed-height tripods are required for all receivers.

For the 5-Centimeter Standard: Fixed-height tripods are preferred for all receivers. When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above mark in both metric units and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

14. A rubbing of the mark must be made at each occupation of a station. When not feasible to make the required rubbing, a plan sketch of the mark must be substituted, accurately recording all markings.

Control Station 1 Control Station 2

Primary Base 1 Primary Base 3

LNS 1 LNS 12

LNS 2 LNS 11

LNS 3 LNS 10

Secondary Base 1 Secondary Base 2

LNS 4 LNS 9

LNS 5 LNS 8

LNS 6 LNS 7

Primary Base 2

Control Station 3

6 Receivers
3 Control Stations (CS)
3 Primary Base Stations (PBS)
2 Secondary Base Stations (SBS)
12 Local Network Stations (LNS)

****

One Week
of
Observations

(1 hour travel time)

CS1, CS2, CS3, PBS1, PBS2, PBS3	Days 1,2, and 3 5-hour sessions (8 a.m.- 1 p.m.)
PBS1, LNS1, LNS2, LNS3, SBS1, LNS4	Day 4 30-minute session (8 am - 8:30 am)
SBS1, LNS4, LNS5, LNS6, PBS2, LNS7	Day 4 30-minute session (9:30 am - 10 am)
PBS2, LNS7, LNS8, LNS9, PBS3, LNS10	Day 4 30-minute session (11 am - 11:30am)
PBS3, LNS10, LNS11, LNS12, SBS2, PBS1	Day 4 30-minute session (12:30 pm - 1 pm)
PBS1, LNS1, LNS2, LNS3, SBS1, LNS4	Day 5 30-minute session (12 pm - 12:30 am)
SBS1, LNS4, LNS5, LNS6, PBS2, LNS7	Day 5 30-minute session (1:30 pm - 2 pm)
PBS2, LNS7, LNS8, LNS9, PBS3, LNS10	Day 5 30-minute session (3 pm - 3:30 pm)
PBS3, LNS10, LNS11, LNS12, SBS2, PBS1	Day 5 30-minute session (4:30 pm - 5 pm)

Figure 1.--Sample project observing scheme.

Vector Processing:

The following requirements are for both 2-centimeter and 5-centimeter standards unless otherwise stated. A summary of the guidelines is listed in table 1 at the end of this section.

1. Final vector processing and quality review of collected data shall be accomplished using NGS' program OMNI or other interactive, graphics-producing software which produces results equivalent to OMNI. The vector between adjacent GPS-occupied stations shall be processed using the multi-station processing technique which includes double-difference phase corelations (or equivalent) with a selection of a reference station that minimizes vector lengths.

2. Use precise ephemerides. NGS' precise ephemerides are available from the U.S. Coast Guard Bulletin Board System or the NGS world wide web site. The Coast Guard Bulletin Board System number is (703)313-5910 and the NGS web site address is http://www.ngs.noaa.gov The USCG web site address is http://www.navcen.uscg.mil/navcen.htm

3. For sessions greater than 30 minutes, process data using 30-second epoch intervals. (Note that using a smaller epoch interval may improve ease of data processing.) For sessions less than 30 minutes, process data using 5-second epoch intervals.

4. For sessions greater than 30 minutes, use only satellite data tracked above the 15-degree elevation angle. For sessions less than 30 minutes, use satellite data tracked above the 15-degree elevation angle; data collected below the 15 degree elevation angle should only be used if required to derive a successful solution.

5. Final processing shall consist of fixing all integers for each vector for all sessions except to some control sites. For short base lines, under 10 km, the L1 fixed solution may be the best choice. For vectors greater than 40 km to control sites, a session may consist of a set of partially or completely fixed vectors and in the worst possible scenario may also include float solutions where no integers could be fixed.

A model to account for tropospheric effects must be used. The project report must state which model was used. Measured meterological data should be used only when it has been determined that the instruments have been properly calibrated and the measurements accurately represent the current atmospheric conditions at the station. If standard meteorological data are used instead of actual measured values, the processing software must account for changes in standard default values due to the station's location and height above the vertical datum. For base lines greater than 15 kilometers or with "large" height differences, a relative tropospheric scale parameter should be solved for, along with the base line vector components.

6. The quality of collected data shall be determined from the double-difference residual plots and RMS values. Final coordinates and their quality assessment shall be determined by using least-squares adjustment software and by analysis of repeated vectors and free-adjustment residuals and loop misclosures (most loops consisting of repeated vectors).

7. RMS values for each computed base line (adjacent station pairs) must not exceed 1.5 cm.

8. Reobservation criteria:

For the 2-Centimeter Standard: For local network requirements, must reobserve any base line (adjacent station pair) where the difference in ellipsoid height between the repeat observations exceeds 2.0 cm. For station pairs involving control stations, must reobserve any control station base line where the ellipsoid height difference between the repeat observations exceeds 5.0 cm.

For the 5-Centimeter Standard: Must reobserve any base line (adjacent station pair) or control station pair where the ellipsoid height difference between the repeat observations exceeds 5.0 cm.

When reobserving base lines that exceed tolerance values, the new observation must agree with an old base line which was observed using the criteria in number 6. of the Observations section above, i.e., the two base line measurements must contain significantly different satellite geometry.

Table 1. -- Summary of Guidelines.

	Control 2 and 5 cm	Primary Base 2 cm	Primary Base 5 cm	Secondary Base 2 cm	Secondary Base 5 cm	Local Network 2 cm	Local Network 5 cm
Dual Frequency Required	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km
Geodetic Quality Antenna with Ground Plane	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Min. Number of Stations	3	3	3	No Minimum	No Minimum	No Minimum	No Minimum
Occupation Time	5 Hours	5 Hours	5 Hours	30 Minutes 1	30 Minutes 1	30 Minutes 1	No Minimum 1
Number of Days Station is Occupied	3	3	3	2 2	2 2	2 2	2 2
Max. Distance Between Same or Higher-Order Stations	75 km	40 km	50 km	15 km	20 km	10 km	20 km
Average Distance Between Stations	No Maximum	No Maximum	No Maximum	No Maximum	No Maximum	7 km	10 km
Repeat "Base Line"	YES 3	YES 3	YES 3	YES 3	YES 3	YES 3	YES 3
Collect Met Data	Yes	Yes	Yes	Yes	Yes	No	No
Fixed Height Pole	Yes	Yes	No	Yes	No	Yes	No
Rubbing of Mark	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precise Ephemerides	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fix Integers	Yes 4	Yes 5	Yes 5	Yes	Yes	Yes	Yes

Notes for Table of Summary of Guidelines:

1 Analyses have indicated that when following all guidelines in this document, 30 minutes of observations over base lines that are typically less than 10 kilometers will meet the standards. For base lines greater than 10 km, but less than 15 km, 1 hour sessions should meet the standards. For observing sessions greater than 30 minutes, collect data at 15-second epoch interval. For sessions less than 30 minutes, collect data at 5-second epoch interval. Track satellites down to at least 10-degree elevation cut-off.

2 Base lines must be reobserved on different days with significantly different satellite geometry.

3 The observing scheme requires that all adjacent stations have base lines observed at least twice on two different days with significantly different geometry.

4 If base line is greater than 40 kilometers, a partially fixed or float solution is permitted.

Data Submission to NGS:

1. The project accession number is of the form GPS-xxx. (The project accession number will be assigned by NGS when draft project plans are submitted to NGS for evaluation prior to the start of the project.)

2. A project report and the data elements listed in Appendix L of "Input Formats and Specifications of the NGS Data Base" must be transmitted to NGS. Quality checks for conformance to NGS format standards shall be performed using software programs COMPGB and OBSDES.

3. Latitude, longitude, and ellipsoid heights, as well as X, Y, and Z coordinates shall be provided in both NAD 83 and ITRF coordinate systems. See Appendix C for more information on transformation parameters and related information.

Guideline Updates:

These Guidelines will be updated as the results of future projects and other procedures are reviewed. There are other procedures that will also achieve the standards. The user should note which procedures in this document were not followed and note how errors and systematic biases were detected, reduced, or eliminated by the new procedure. NGS welcomes the opportunity to examine alternate procedures and supporting data that demonstrate the ability to achieve the accuracy standards stated in this document. If you have such data or would like to comment, please contact Dave Zilkoski or Steve Frakes, telephone 301-713-3191, or write:

National Geodetic Survey, N/NGS2
NOAA, 1315 East-West Highway
Silver Spring, Maryland 20910-3282
email: davez@ngs.noaa.gov or
steve@ngs.noaa.gov

Appendix A. -- Definitions

Accuracy

Local Accuracy - The local accuracy of a control point is a value expressed in cm that represents the uncertainty in the coordinates of the control point relative to the coordinates of the other directly connected, adjacent control points at the 95 percent confidence level. The reported local accuracy is an approximate average of the individual local accuracy values between this control point and other observed control points used to establish the coordinates of the control point.

Network Accuracy - The network accuracy of a control point is a value expressed in cm that represents the uncertainty in the coordinates of the control point with respect to the geodetic datum at the 95 percent confidence level. For National Spatial Reference System (NSRS) network accuracy classification, the datum is considered to be best supported by NGS. By this definition, the local and network accuracy values at CORS sites are considered to be infinitesimal, i.e., to approach zero.

Stations

Base Stations

Primary - Stations evenly distributed that surround the local network. These stations relate the local network to NSRS to the 5-cm, or better, standard through simultaneous observations with control stations. They can be newly established stations and be part of the local network.

Secondary - Stations evenly distributed throughout the local network that ensure that the local network does not contain a significant medium wavelength (20-30 km) ellipsoid height error through simultaneous observations with primary base stations. These stations may be newly established stations and are part of the local network. They are located between Primary Base Stations.

Control Stations

A- or B-order three-dimensional stations that surround the project area in at least three different quadrants. These stations relate the local network to the National Spatial Reference System through simultaneous observations with primary base stations. They must be referenced to NSRS and they provide the network accuracy. They may be newly established stations in the survey project if A- or B-order specifications and procedures are used to establish them. These procedures are not covered in this document, please contact NGS for additional information.

Local Network Stations

These stations include all other stations that are not base (primary or secondary) or control stations. They are part of the local network. They provide the local accuracy standard through simultaneous observations between adjacent stations.

Appendix B. -- GPS Ellipsoid Height Hierarchy and Basic Requirements for 2-cm standard

```
                          HARN/Control Stations

                                (75 km)

                              Primary Base

                                (40 km)

                             Secondary Base

                                (15 km)

                         Local Network Stations

                             (7 to 10 km)

                         HARN/Control Stations

                                 O CS1

         O CS2 <--------------------75 km------------------> O CS3

                          Primary Base Stations

                                 O CS1

                                  PB1

         PB2 <----------------------40 km--------------------->PB3

 O CS2                                                               CS3 O
```

Basic Requirements

- o 5 Hour Sessions / 3 Days
- o Spacing between primary base stations cannot exceed 40 km.
- o Each primary base station must be connected to at least its nearest primary base station neighbor and nearest control station.
- o Primary base stations must be traceable back to 2 control stations along independent paths; i.e, base lines PB1 - CS1 and PB1 - PB2 plus PB2 -CS2, or PB1 - CS1 and PB1 - PB3 plus PB3 - CS3.

Secondary Base Stations

O

PB1

SB1 SB2

SB3 <---------- 15 km ---------- > SB4

PB2 PB3

O O

Basic Requirements

- o 30 Minute Sessions / 2 Days / Different times of the day
- o Spacing between secondary base stations (or between primary and secondary base stations)cannot exceed 15 km.
- o All base stations (primary and secondary) must be connected to at least its two nearest primary or secondary base station neighbors.
- o Secondary base stations must be traceable back to 2 primary base stations along independent paths; i.e., SB1- PB1 and SB1- SB3 plus SB3 - PB2, or SB1 - PB1 and SB1 - SB4 plus SB4 - PB3.
- o Secondary base stations need not be established in surveys of small areal extent.

```
                        Local Network Stations

                                   O

                                  PB1

                                  LN1

                  SB1          LN2      LN3          SB2

                  LN4                                LN5

                            LN6<--7 km -> LN7
                  SB3                                SB4

            PB2                                            PB3

       0                                                          0
```

Basic Requirements

- o 30 Minute Sessions / 2 Days / Different times of the day
- o Spacing between local network stations stations (or between base stations and local network stations) cannot exceed 10 km.
- o All local network stations must be connected to at least its two nearest neighbors.
- o Local network stations must be traceable back to 2 primary base stations along independent paths; i.e., LN1 - PB1 and LN1 - LN2, plus LN2 - SB1, plus SB1 - SB3 plus SB3 - PB2, or LN1 - PB1 and LN1 -LN3, plus LN3 - SB2 plus SB2 - SB4 plus SB4 - PB3.

APPENDIX C.--ITRF TO NAD 83 TRANSFORMATION PARAMETERS

Introduction

The International Earth Rotation Service Terrestrial Reference Frame (ITRF) has become an important coordinate system for users of Global Positioning System (GPS) technology. Both GPS and ITRF are global, geocentric coordinate systems. The ITRF coordinate system supports GPS orbit computations and provides a basis for more precise GPS data reduction computations. Also, for many applications it is necessary to use a coordinate system such as ITRF to account for the motions of the Earth's crust. Published ITRF solutions provide not only coordinate values at a particular epoch in time, but station velocities as well. Thus, up-to-date ITRF station coordinate values can be computed for future epochs in time after the original solution.

The North American Datum of 1983 (NAD 83), on the other hand, has the advantage of being fixed and stable relative to the North American tectonic plate. Additionally, NAD 83 has been officially adopted by the Federal government as the coordinate system for mapping and charting in the Unites States. Therefore, the relationship of ITRF to regional or continental datums like NAD 83 is of utmost importance to GPS users.

The following background information on NAD 83 should help understanding the differences, systematic and otherwise, between ITRF and NAD 83.

NAD 83 Datum Definition

The NAD 83 adjustment combined terrestrial data (distances, azimuths, and direction observations) with space-based data, such as 3-D positions derived from satellite Doppler observations and 3-D inter-station vectors obtained from Very Long Baseline Interferometry (VLBI).

Along with these data, and equally important, was a set of implied constraints that defined the scale and orientation of NAD 83. Also included in the NAD 83 adjustment was a set of global parameters that allowed the implied constraints to have complete influence. An example would be that of a distance observation which has implied scale, but if a global scale parameter is included in its observation equation, it allows the scale to be determined elsewhere. Table 1 shows the global parameters for the NAD 83 adjustment:

Table 1.--Global parameters - NAD 83 adjustment.

Parameter	Terrestrial	Doppler	VLBI
X Shift		F	
Y Shift		F	
Z Shift		F	
X Rotation		F	A
Y Rotation		F	A
Z Rotation	F	A	A
Scale	A	F	A

F=fixed parameter
A=estimated parameter

The above table shows that the 3-D positions derived from Doppler observations defined the geocentricity, scale, and the major part of the orientation of the NAD 83 datum.

The VLBI vectors are very important for several reasons. To begin with, the VLBI vectors are extremely precise. These vectors span the continent and are found to be internally consistent at the 2-3 cm level. Second, the VLBI stations and data are an integral part of the ITRF solutions and thus provide a link between NAD 83 and ITRF. Third, although the VLBI vectors were not used to help define the NAD 83 scale and orientation, the adjusted values for global parameters associated with the VLBI vectors tell how they were changed. This provides a quantitative measure of the systematic difference between NAD 83 and coordinate systems based on VLBI.

Table 2.--Adjusted values for VLBI global parameters.

Parameter	Value
X Rotation	0.022 arc seconds
Y Rotation	0.026 are seconds
Z Rotation*	0.010 arc seconds*
Scale Change	-0.075 ppm

*The actual adjusted value of the Z rotation was 0.375 arc seconds, however there was a post-adjustment correction of 0.365 arc seconds applied, resulting in the 0.010 arc seconds shown above. In effect the coordinate system was rotated to be more consistent with the VLBI observations.

NAD 83 Upgrade Surveys

In 1988, the National Geodetic Survey (NGS) began to upgrade the NAD 83 coordinates by performing high accuracy reference network (HARN) GPS surveys. This is being done on a state-by-state basis. The strategy for determining the control for these upgrades follows. First consider the following (X, Y, Z) transformation, designated equation 1:

$$Xn = Tx + (1 + S)Xi + RzYi - RyZi$$

$$Yn = Ty - RzXi + (1 + S)Yi + RxZi$$

$$Zn = Tz + RyXi - RxYi + (1 + S)Zi$$

This equation defines a seven-parameter transformation from ITRF to NAD 83, where (Xi, Yi, Zi) denote geocentric cartesian coordinates in ITRF and (Xn, Yn, Zn) denote geocentric cartesian coordinates in NAD 83.

In order to establish control stations for the new HARN GPS surveys, NGS completed the following:

1. NGS used a set of 12 VLBI stations located in North America to determine a seven-parameter transformation (equation 1) from ITRF89 (epoch 1988.0) to NAD 83 (see table 3).

2. NGS decided to accept the scale of ITRF89 as being closer to the true value.

3. The derived transformation parameters, translations, and rotations, but NOT scale, were applied to the complete set of ITRF89 positions to get NAD 83 values with corrected scale. A comparison with the original NAD 83 coordinates showed a change in ellipsoid height of 0.6 meters, which was caused by scale differences.

Table 3.--Transformation parameters, ITRF89 (Epoch 1988.0) to NAD 83.

Parameter	Value
Tx = X Shift	0.9191 meters
Ty = Y Shift	-2.0182 meters
Tz = Z Shift	-0.4835 meters
Rx = X Rotation	0.0275 arc seconds
Ry = Y Rotation	0.0155 arc seconds
Rz = Z Rotation	0.0107 arc seconds
S = Scale Change	-0.0871 ppm [See item 3) above.

Apparent in Table 3 is the similarity of the values for the rotations and scale with those in Table 2. This indicates that the coordinate system of the original VLBI vectors is very similar to ITRF.

Computations of GPS Data in ITRF

Several other solutions of ITRF have been computed by the International Earth Rotation Service since the publication of ITRF89. As more and more data have been collected and included in the ITRF solutions, the resulting coordinates and velocities have increased in accuracy. Confidence in ITRF has grown to the point that most geodetic organizations throughout the world now use ITRF as a basis for GPS orbit computations.

An important concept for the GPS user community to understand is that since GPS precise orbits are referred to ITRF, fixed orbit solutions of GPS produce vectors that are oriented in the ITRF coordinate system. However, most of the user community is working in NAD 83. The systematic differences between ITRF and NAD 83 must be accounted for, if high accuracy is to be maintained.

Since we are dealing with inter-station vector components, instead of positional coordinates, we need not worry about X, Y, Z shifts. Also, recall that the scale of NAD 83 was corrected when the high accuracy GPS survey began. But the X, Y, Z rotations between ITRF and NAD 83 must be accounted for. NGS adjustment software ADJUST does just that. ADJUST accepts GPS vectors expressed in ITRF as well as other coordinate systems as input, then, internal to the program, applies the X, Y, Z rotations to convert to NAD 83.

Table 4 describes transformation parameters between NAD 83 and some more recent solutions of ITRF.

Table 4.--Transformation parameters: ITRF solutions to NAD 83.

Parameter	ITRF93 (Epoch 1995.0)	ITRF94 (Epoch = E, in years)
Tx = X Shift	0.9769	0.9738 meters
Ty = Y Shift	-1.9392	-1.9353 meters
Tz = Z Shift	-0.5461	-0.5486 meters
Rx = X Rotation	0.0264	0.02755 + 0.00009(E-1996.0) arc sec
Ry = Y Rotation	0.0101	0.01005 - 0.00077(E-1996.0) arc sec
Rz = Z Rotation	0.0103	0.01136 + 0.00002(E-1996.0) arc sec
S = Scale Change	0.0	0.0 ppm

NOAA TECHNICAL PUBLICATIONS

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Appendix 4

Data Processing and Analysis

CONTENTS

*Note: This XML file can be downloaded from the Appendices by selecting the Attachments pane, right-clicking on the file name, and selecting "Save Attachment."

Ellipsoidally Referenced Surveys
Standard Operating Procedure

Corey Allen
Manager / Process Owner Approval

Revision History

Date	Revision Description (Reason/What)	Updated by
3/7/2011	New Document	JCA
4/3/2012	Minor Edits	JCA

(Latest change at the top of the table)

CONTENTS

1. OVERVIEW

This SOP outlines processing procedures to process an Ellipsoidally Referenced Survey (ERS). Any errors or concerns with the technical information herein should be addressed to Corey Allen (Corey.Allen@noaa.gov) or Steve Brodet (Steve.Brodet@noaa.gov).

2. GLOSSARY OF PROCESSING TECHNIQUES

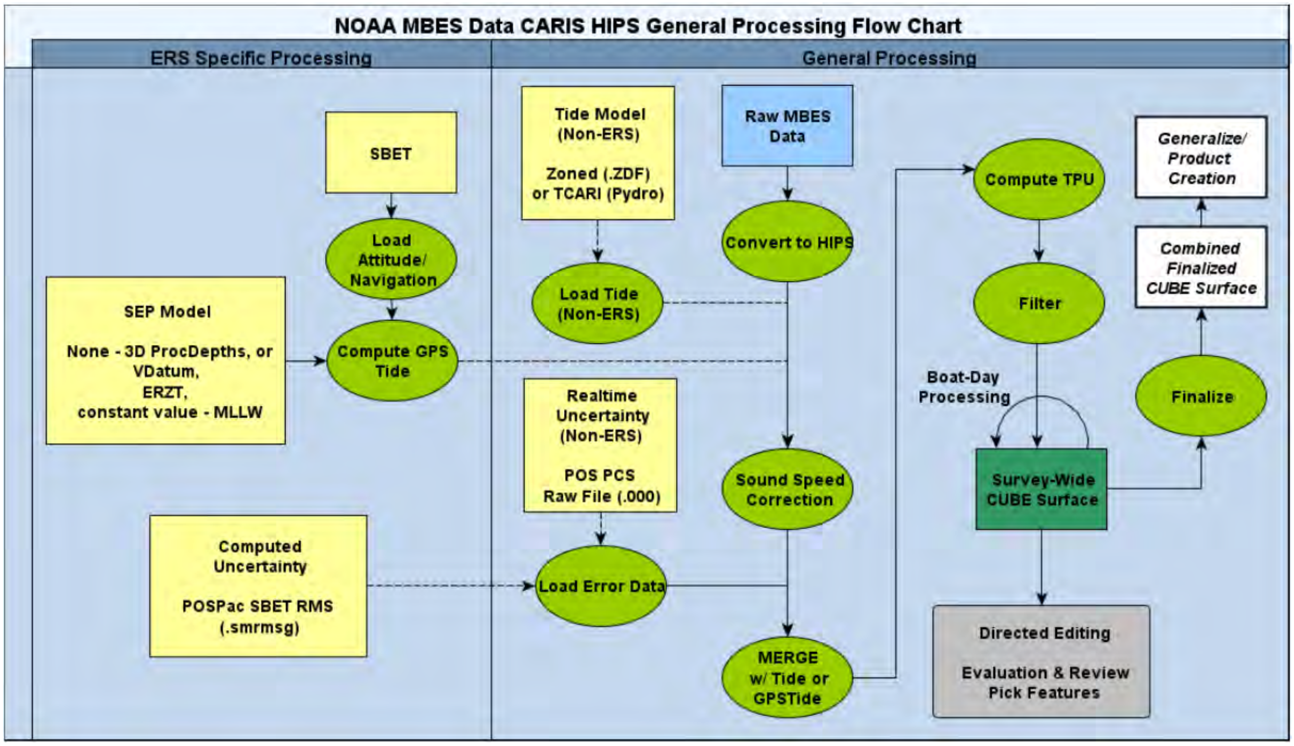
Applanix IN-Fusion Single Baseline "SingleBase" - One dedicated base station is used to process a tightly coupled solution for short base line processing up to approximately 20km. The base station may be user-installed or downloaded form the various available networks (CORS/IGS/SOPAC). Ephemeris corrections should be downloaded to obtain to highest level of precision of ephemeris available at the time of processing (e.g. Ultra-Rapid, Rapid, Precise).

Applanix IN-Fusion Smartbase – Smartbase processing is based on Trimble VRS technology, the virtual reference station solution that uses a network of user-installed or continuously operating reference stations to compute a set of correctors for the roving receiver anywhere within the network. Smartbase processing requires a minimum of four reference stations surrounding the rover, but distance to the nearest reference station can be extended to 70km.

Applanix IN-Fusion PPP – Precise Point Positioning is a processing method that provides positioning accuracies on the order of a few decimetres without needing a reference station. This application is useful when a reference station cannot be found or installed within allowable distance tolerances.

3. FLOWCHART OR WORKFLOW

The following figure shows the NOAA MBES Data Processing Flow Chart



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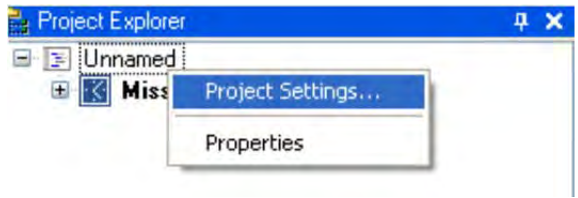
USING POSPAC MMS 5.4 TO PROCESS GPS (SINGLEBASE)

SINGLEBASE STANDARD PROCESING

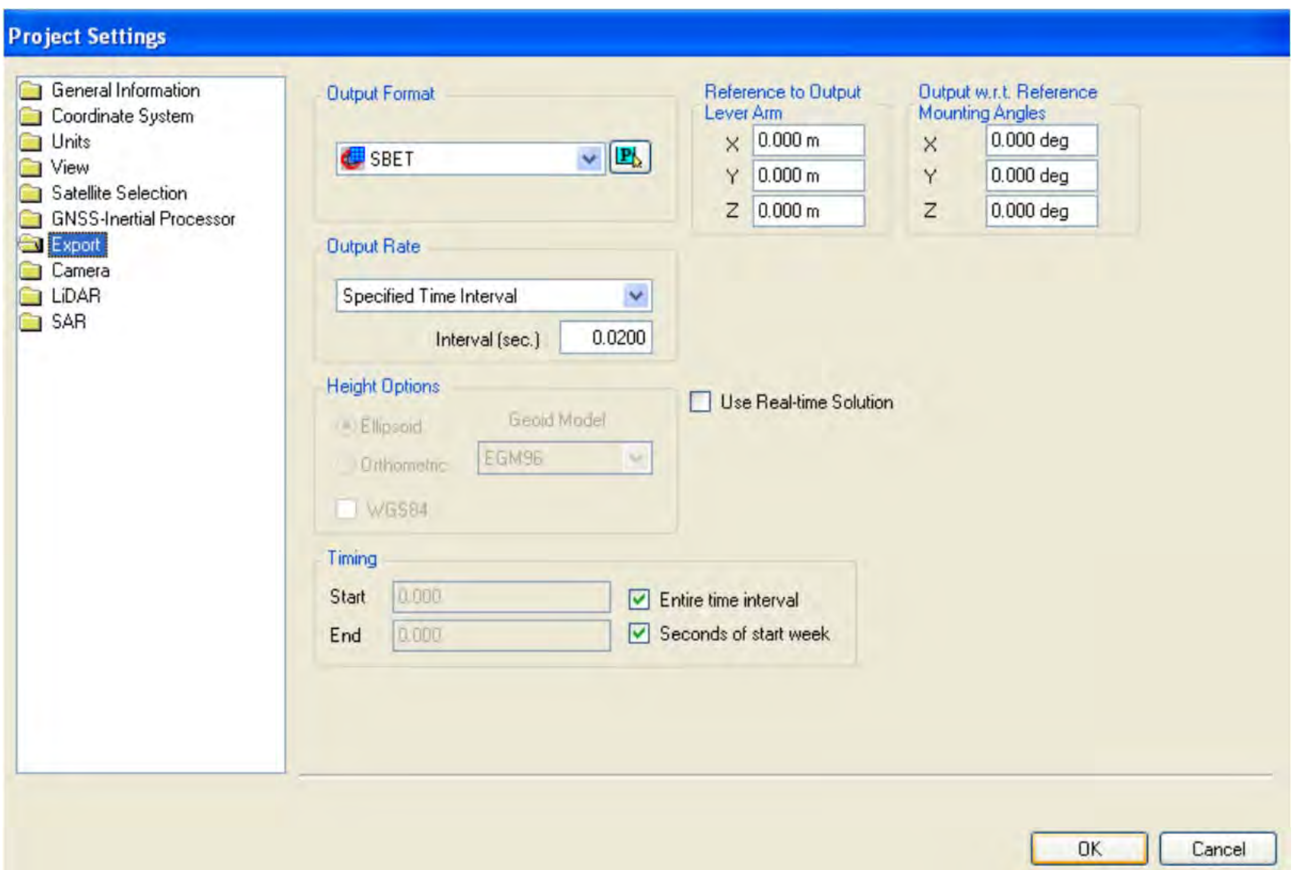
Step One: Create POSPac MMS 5.4 Template

• File, New Project, double click on <Blank Template>

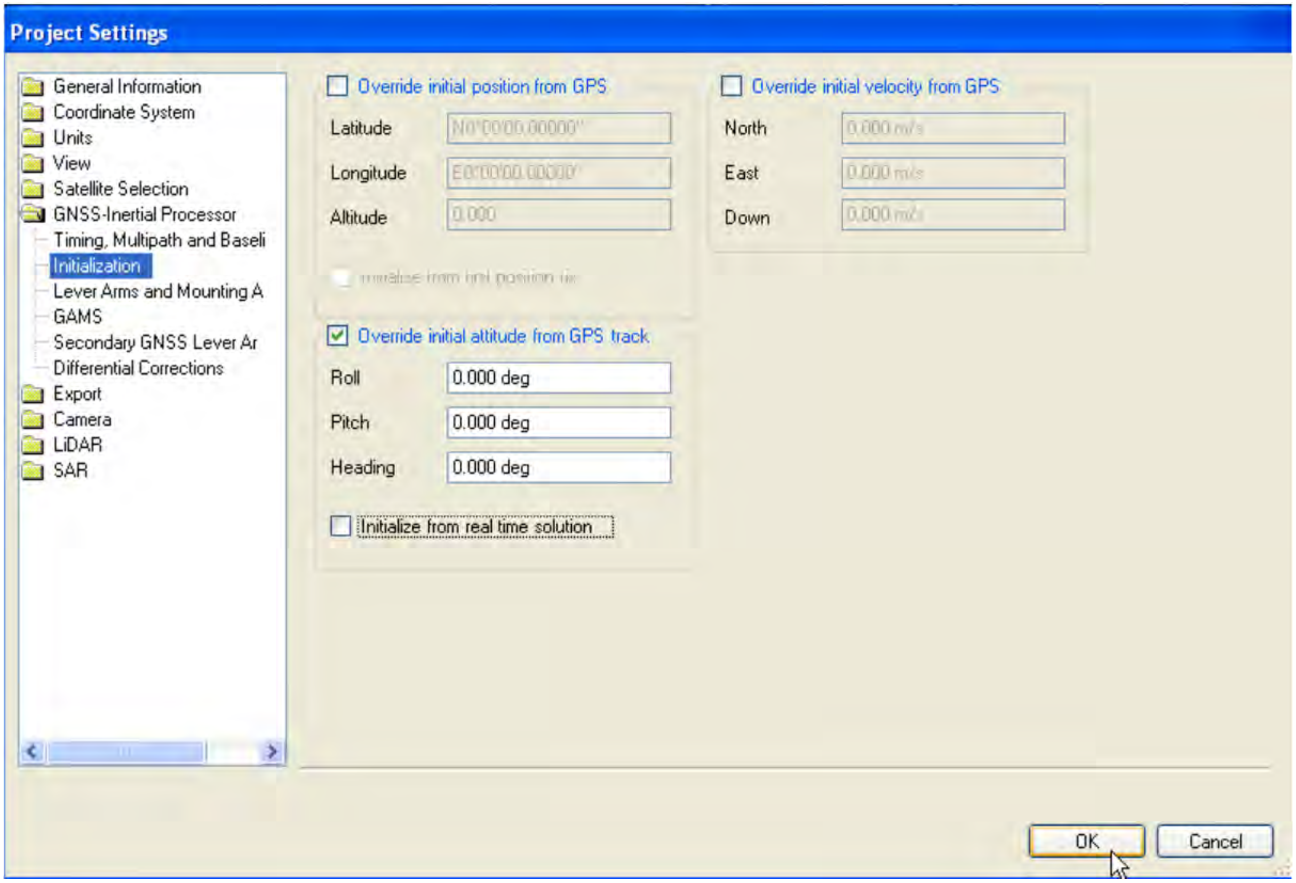
• Under Project Explorer, right mouse click on Unnamed and select Project settings



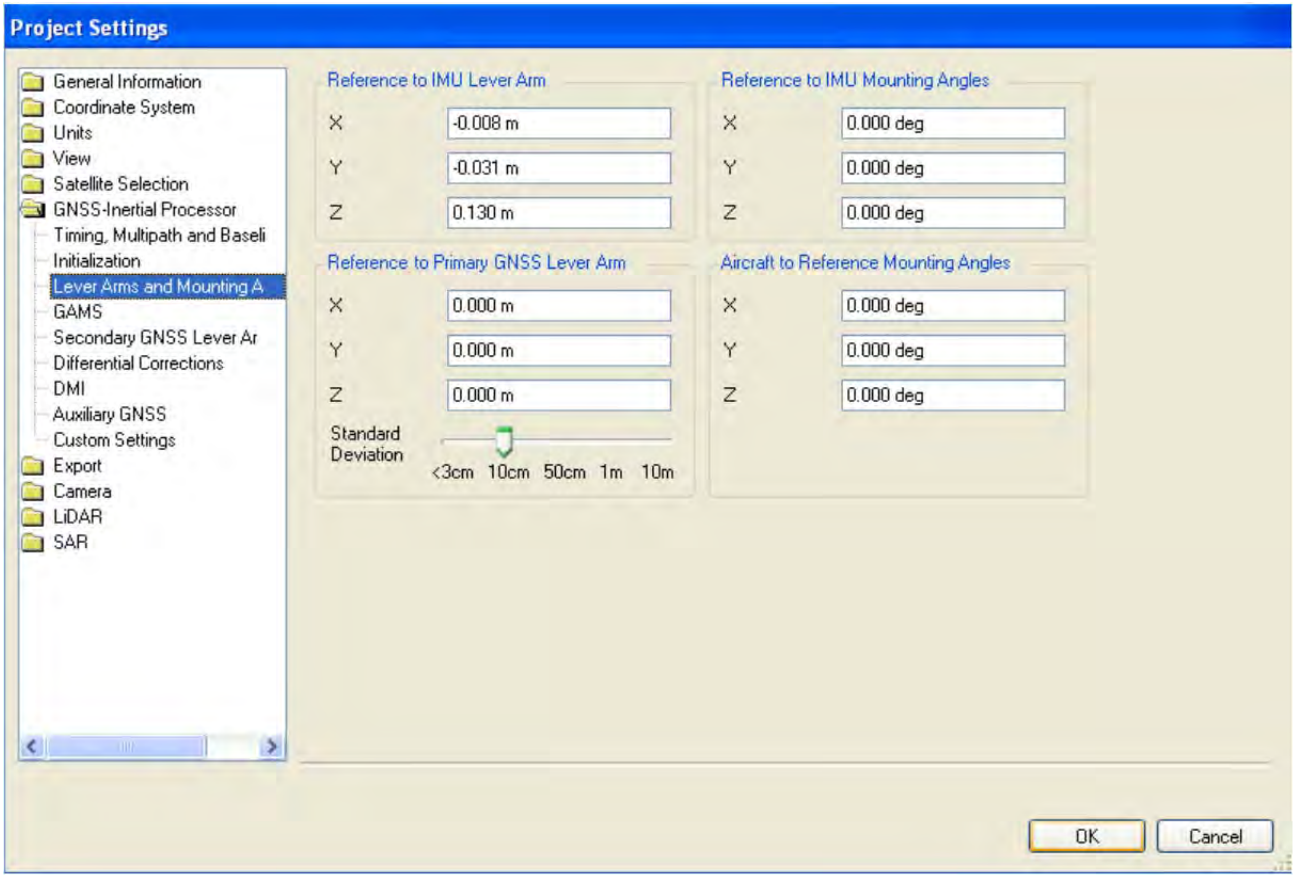
• Navigate to the export tab and change the output format to "SBET" with an output rate "specified time interval" of 0.02 seconds. Unclick "Use Real-Time solution" box.



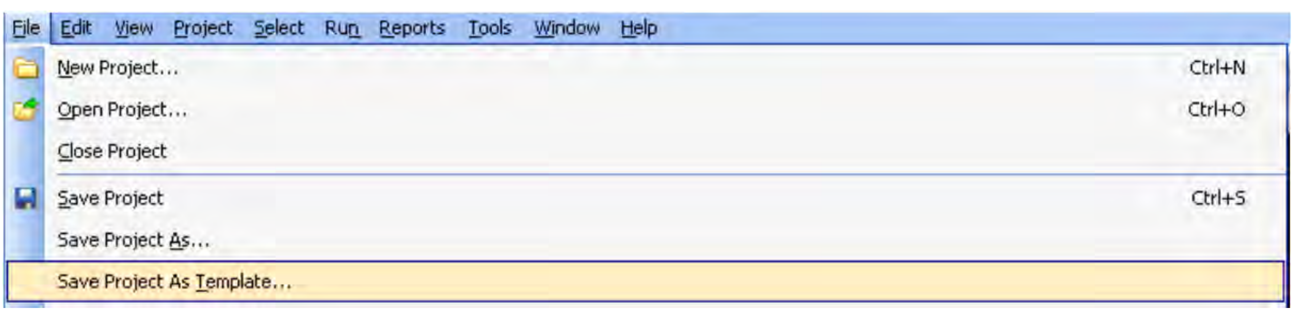
• Navigate to the Initialization tab and ensure the Initialize from real time solution box is *unchecked*



• Navigate to the Lever Arms and Mounting Angles tab and enter Reference to IMU Lever Arm values as shown (-0.008, -0.031,and 0.130):



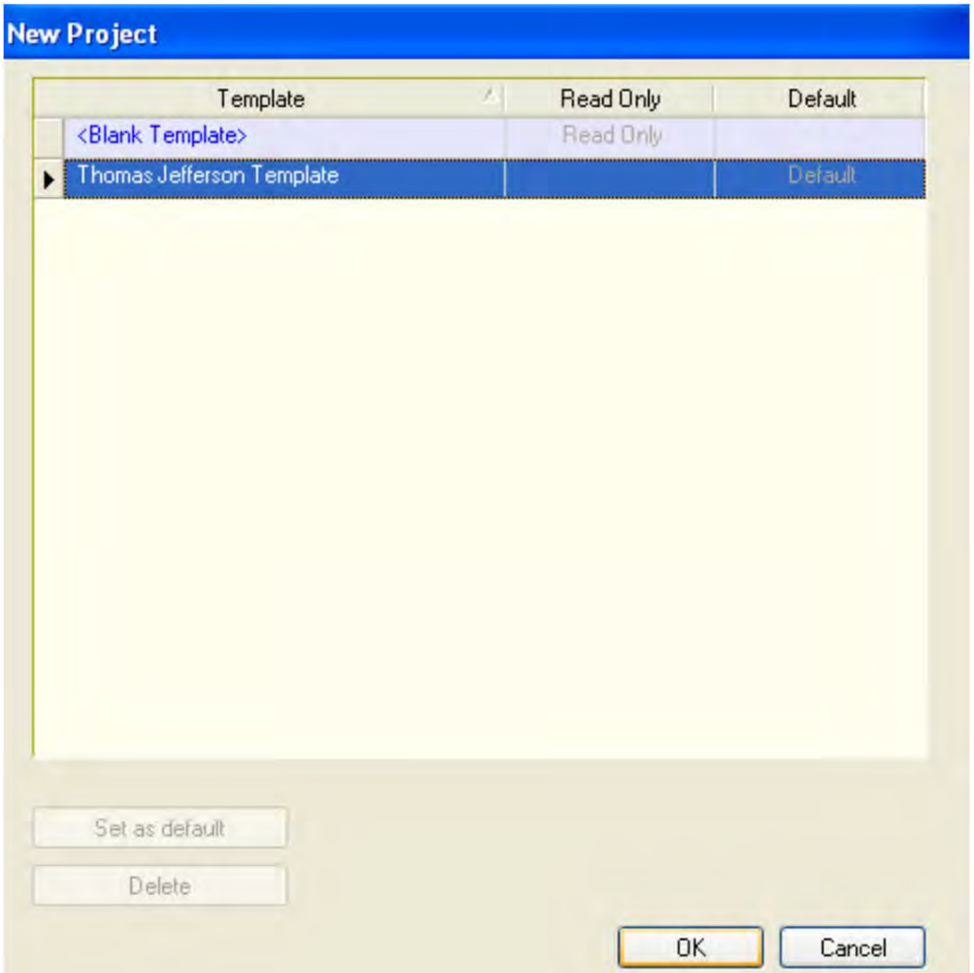
• File, Save Project As Template



• Name the template *NOAA_SHIP_Template* and click the set as default button, then ok

Step Two: Create a POSPac 5.4 Project:

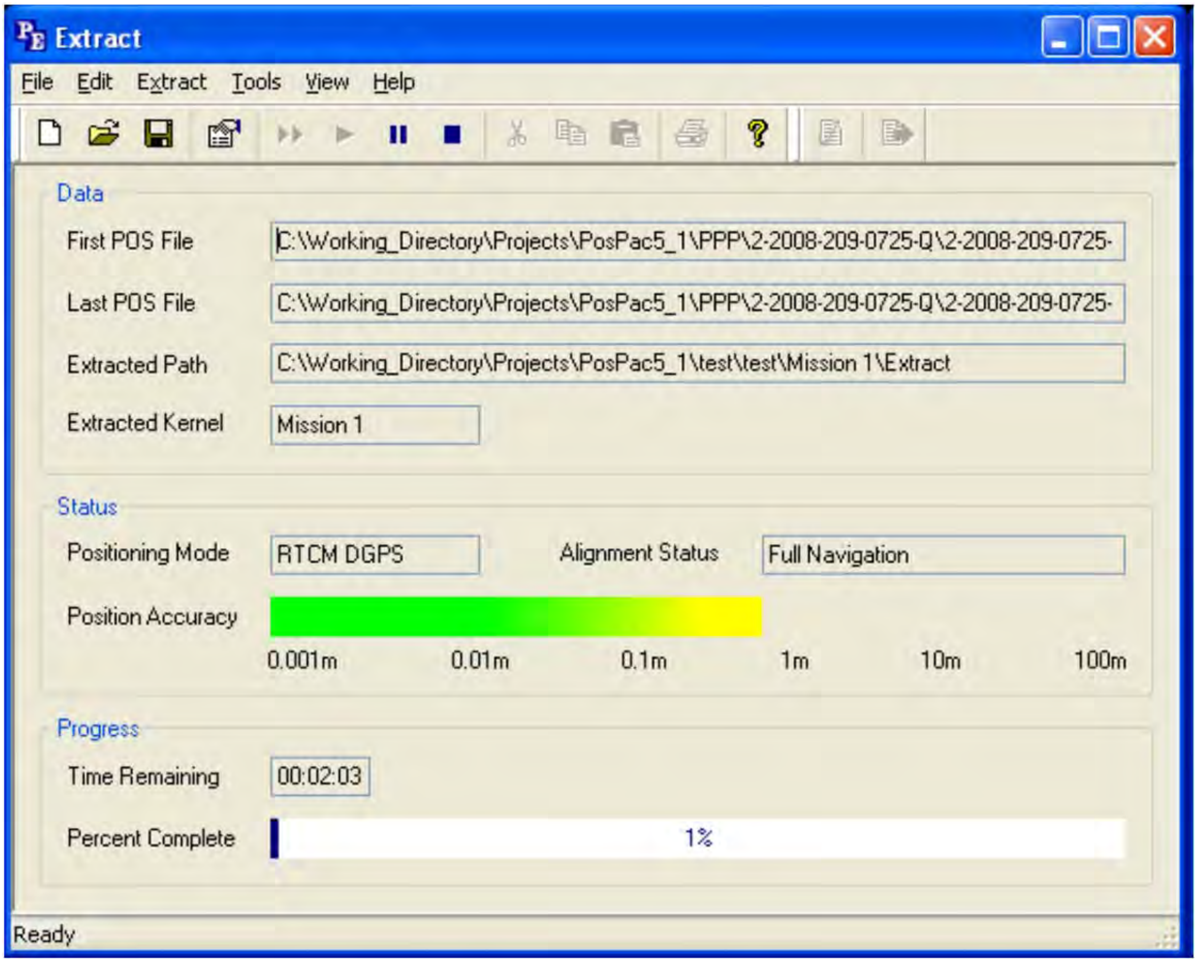
• File, New project. Highlight the template created in Step One and click OK



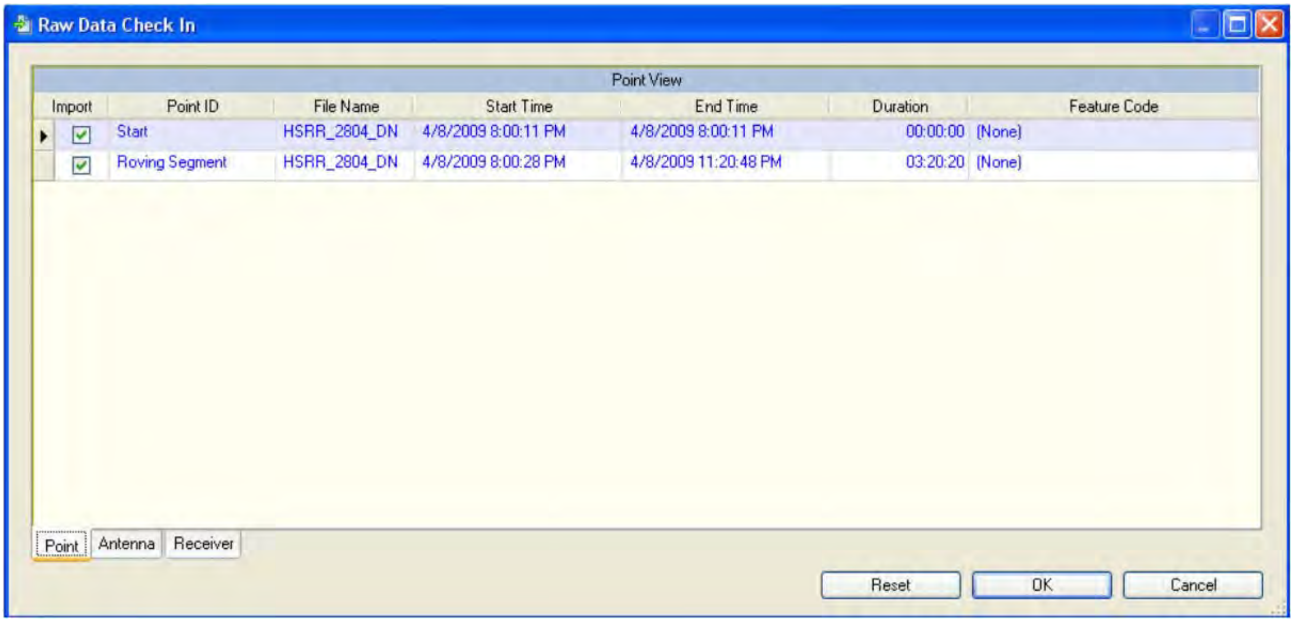
• File, Save Project. Save as *Year_JulianDay_Vessel*

Step Three: Import the Raw POS

• Open a windows explorer window and locate the UNFIXED true heave file for the specific project, vessel and day. **Drag and Drop your .000 file into the Plan View window**



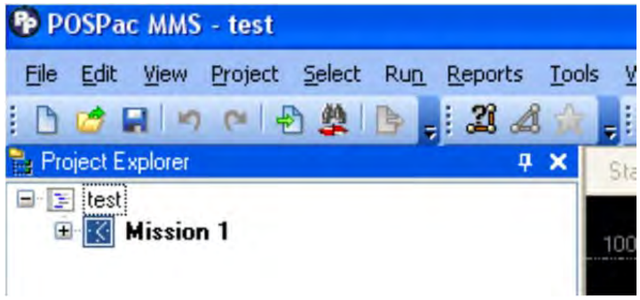
• Say OK at the following window. Antenna and Receiver should remain unknown for the POS data.



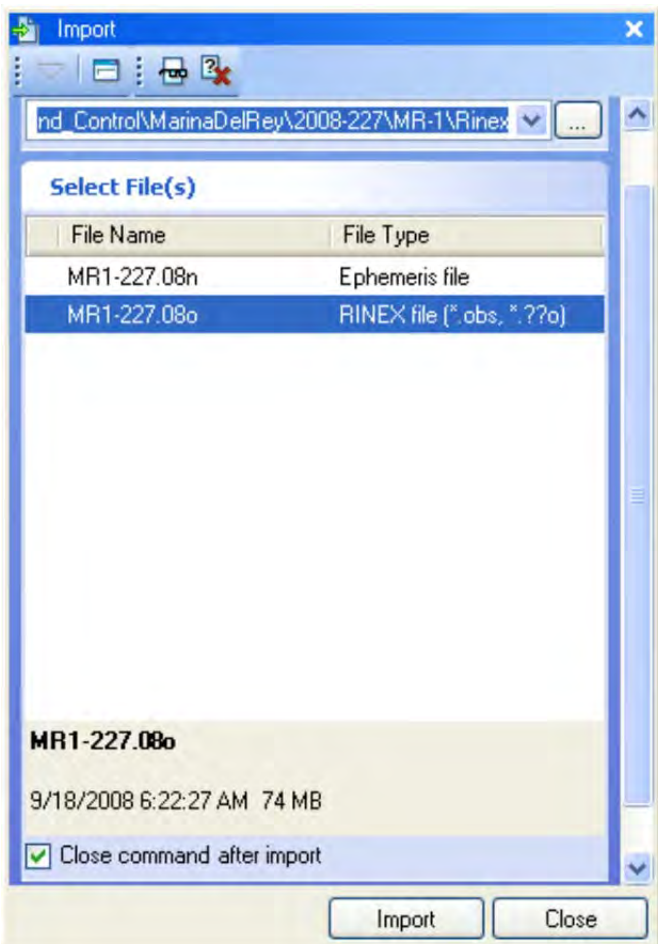
• The project definition can remain unchanged. Simply select "OK"

Step Four: Import raw Base Station GPS data (Rinex Format)

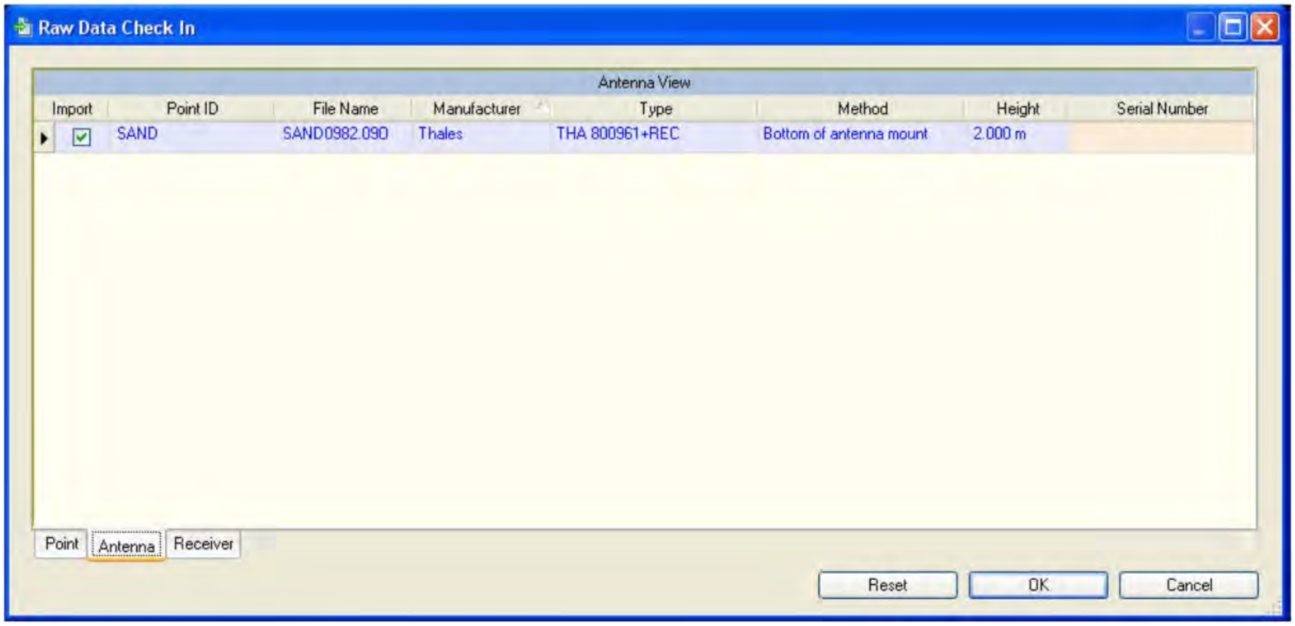
• From the toolbar, select Import or go to Project in the top Menu and then select Import or drag and drop from a windows explorer window.



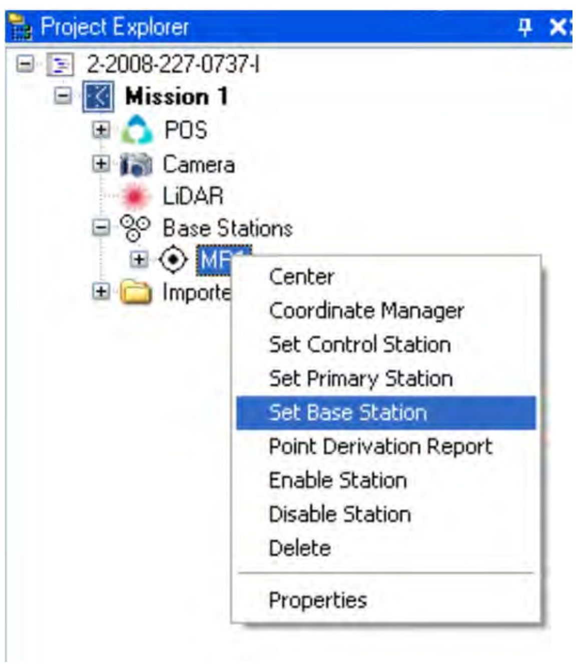
• Browse to the appropriate Ground_Control directory and select the Rinex file or files (*.YYo) you wish to Import. Note: Ensure that the Rinex file or files covers the entire POS file you are processing where bathymetric data exists



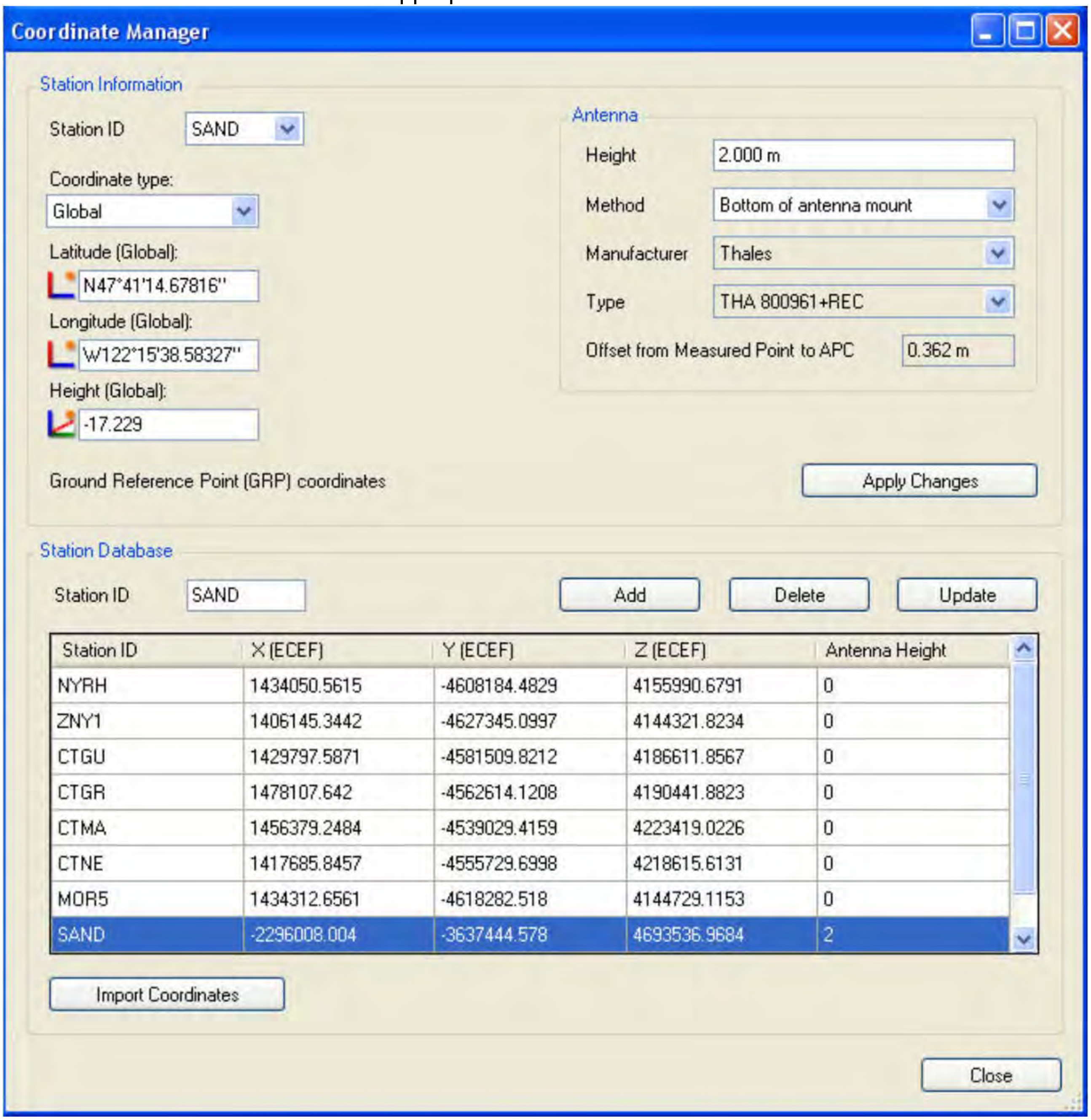
When the Base Station data is finished importing the Raw Data check in window will appear; here we need to specify the Manufacturer, Type, and Height of tripod of the GPS Base Station. In this case it was a Thales receiver, THA800961+REC antenna type, and 2.00m fixed height tripod.



Right mouse click on the base station (in this case named SAND) and select Set Base Station NOAA

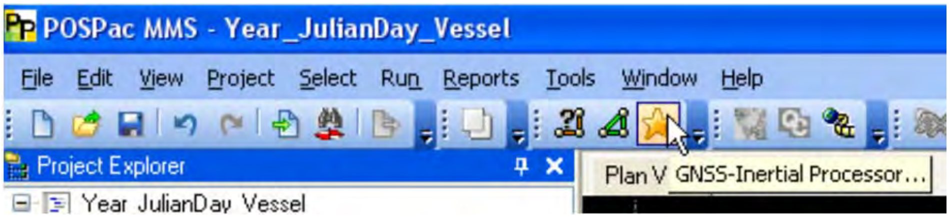


Then right mouse click on the SAND again and select Coordinate Manager and either input the NAD83 coordinates for the station obtained from the OPUS report or if it has previously been input as NAD83 then double click on the appropriate Station ID list to select the station.

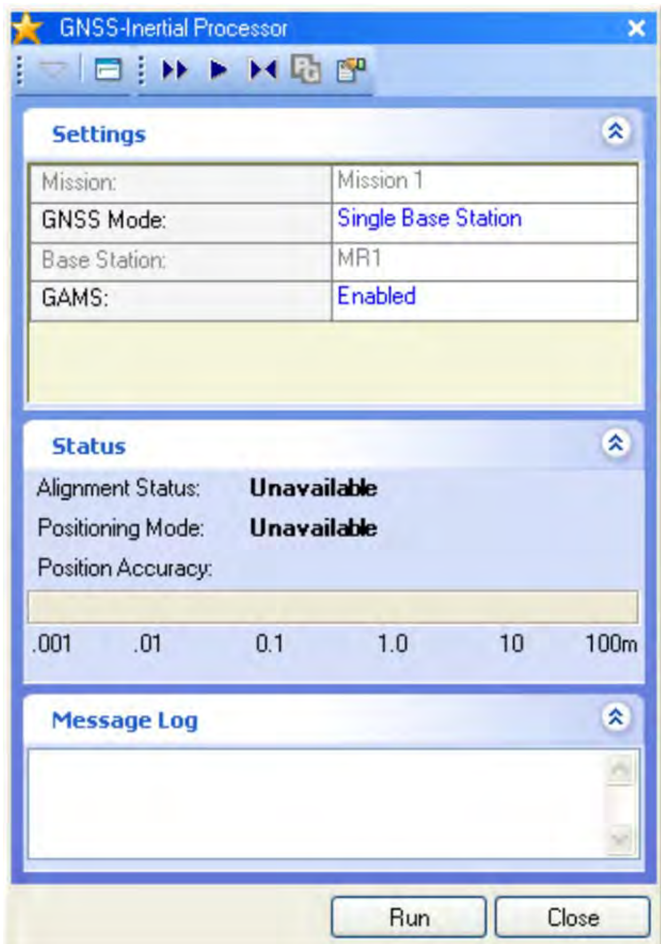


Step Six: GNSS Inertial Processor using Single Base

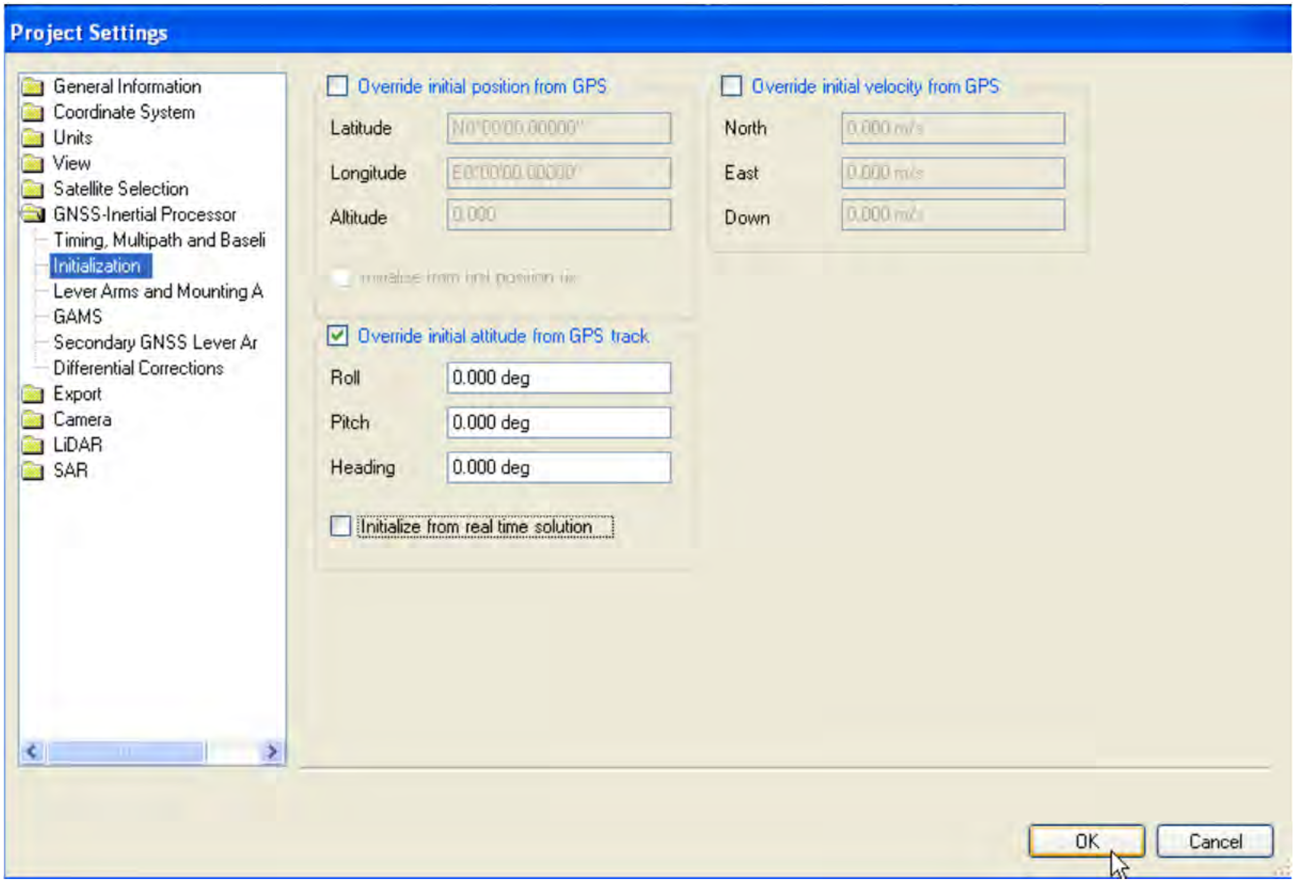
• From the toolbar select Process or go to Run on the top Menu and then select GNSS Inertial Processor.



• From the pull down menu across from the GNSS Mode select Single Base



• In the Initialization tab, ensure the “initialize from real time solution” box is *unchecked* and click OK



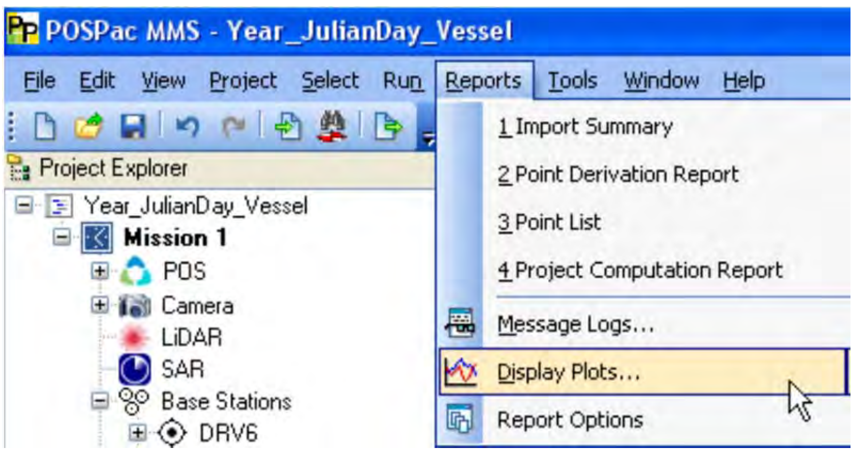
• Select Run, or click on the Forward, Backward and Combine icon to run the GNSS-Inertial processor

• Close when completed. The track lines should now appear green representing the data has been corrected with a fixed integer solution.

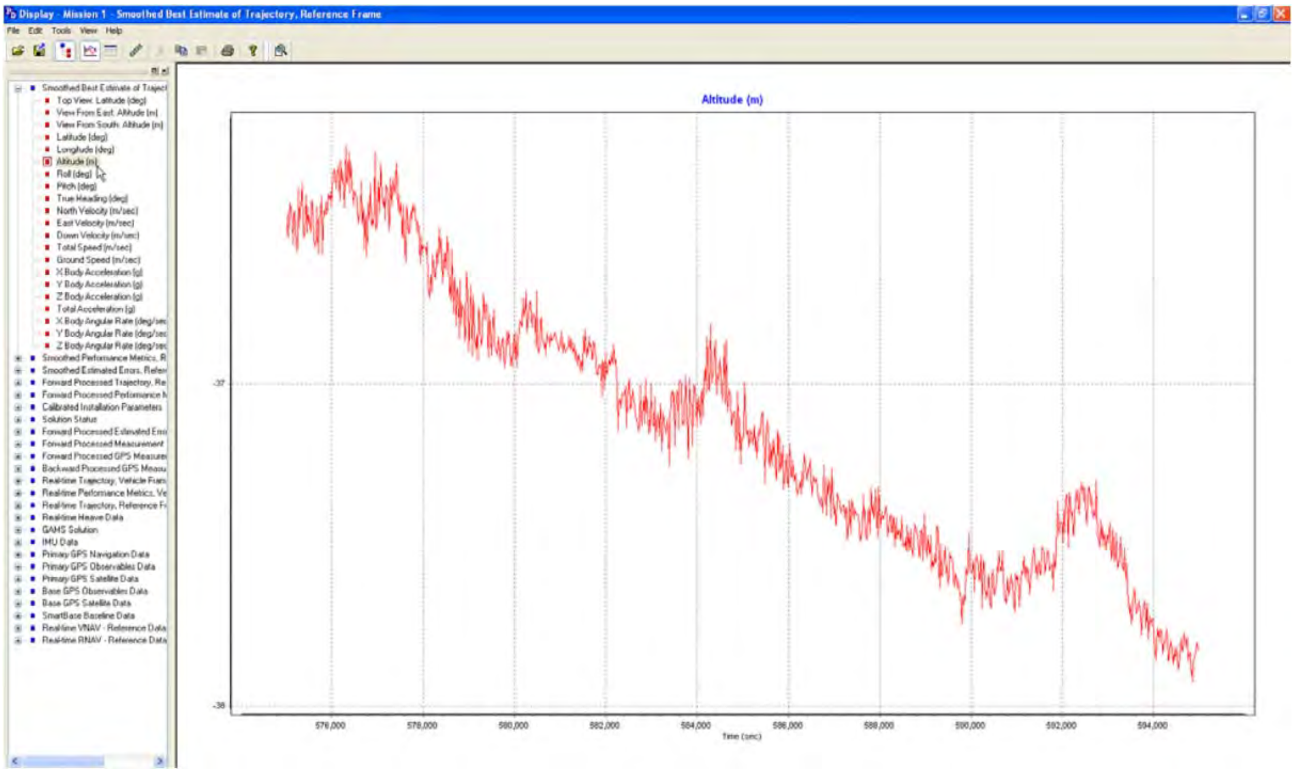
Step Seven: Quality Control Checks for the SBET

• Examine the message logs for the solution. Look for serious errors, cycle slips and data gaps.

• Examine the plots for the solution. There are multiple ways to examine the data. When examining the data, ensure the HXXXXX_SBET_Checksheet.xlsx is filled out.

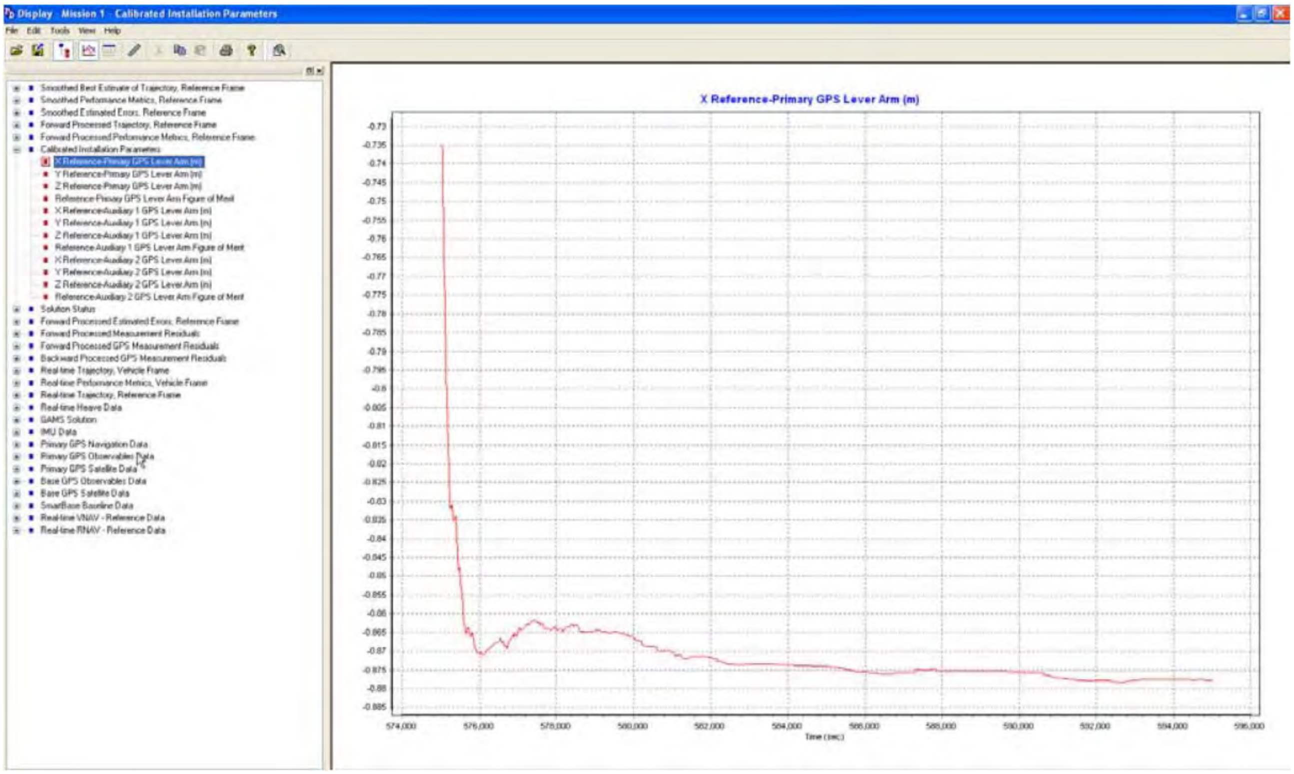


o **Altitude**. Found under “Smoothed Best Estimate of Trajectory” and “Altitude.” Oscillation is normal as it reflects vessel motion, and usually a general tidal trend can be seen. Large spikes should not be present; since this is the computed altitude the error will definitely carry through to any data the SBET is applied too. If large spikes are present, try alternate processing methods. The following is normal:

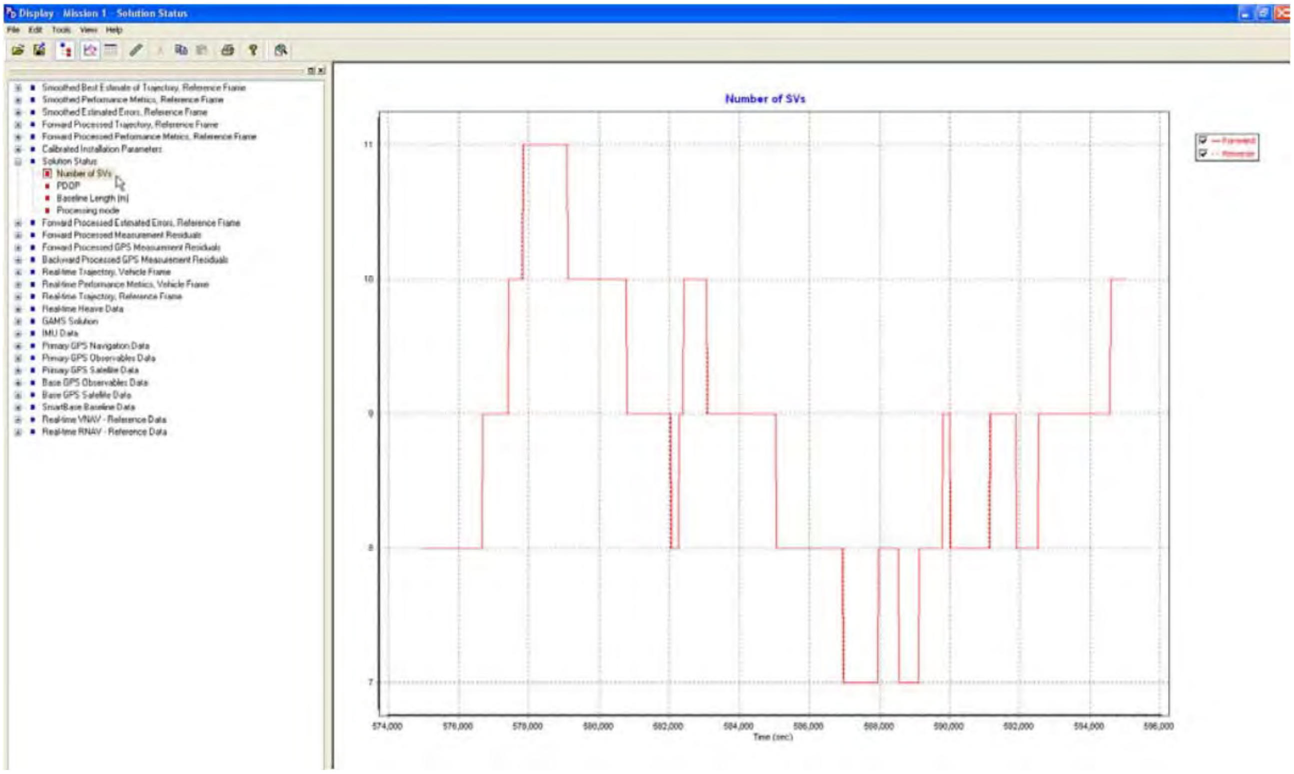


o **RMS Data.** Found under “Smoothed Performance Metrics, reference frame” and North, East, and Down Position Error RMS (m). The RMS should be better than 10 cm (not including the first and last spike when no line data is being logged). A more realistic error is less than 5cm. The example below is about .04m.

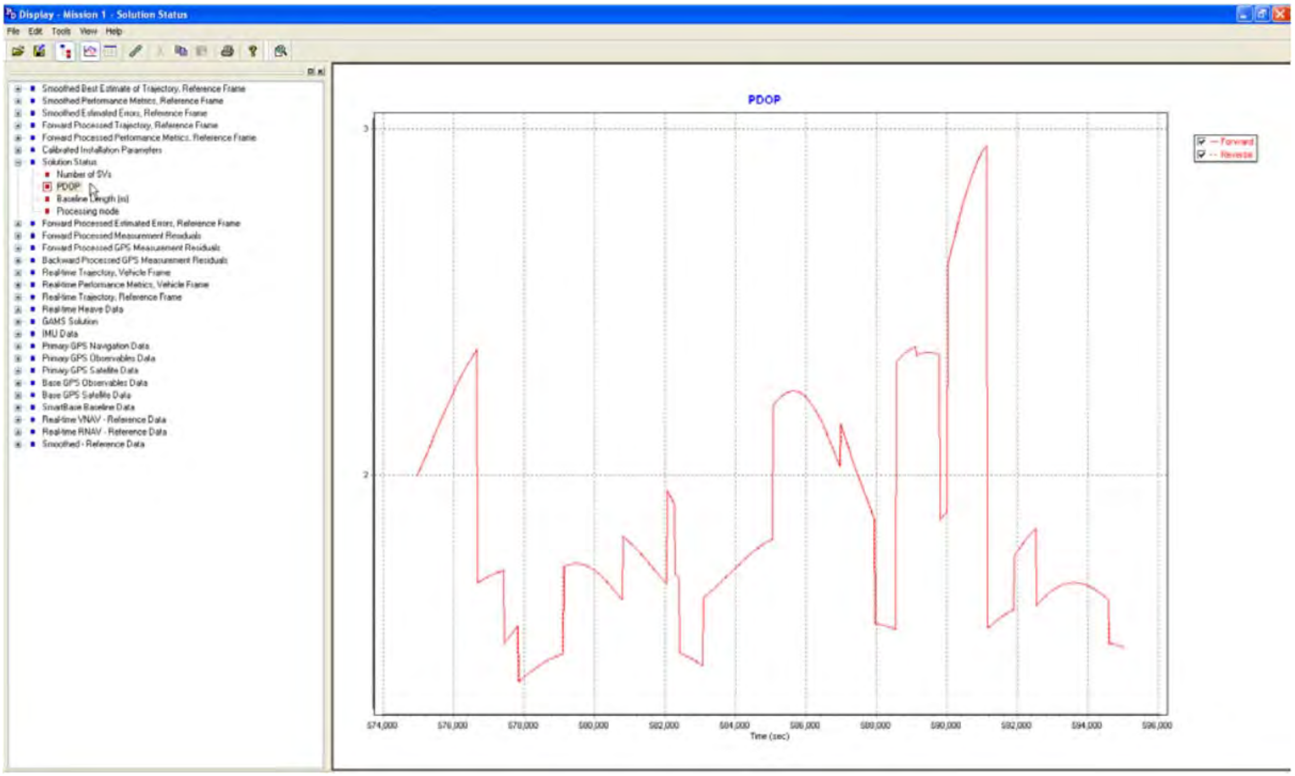
o **Calibrated Installation Parameters.** Found under “Calibrated Installation Parameters” and then X, Y, and Z Reference- Primary GPS Lever Arm. These values should settle out to an approximate value for x, y and z. Record these settled values in the SBET Check sheet and look for similar values for each vessel.



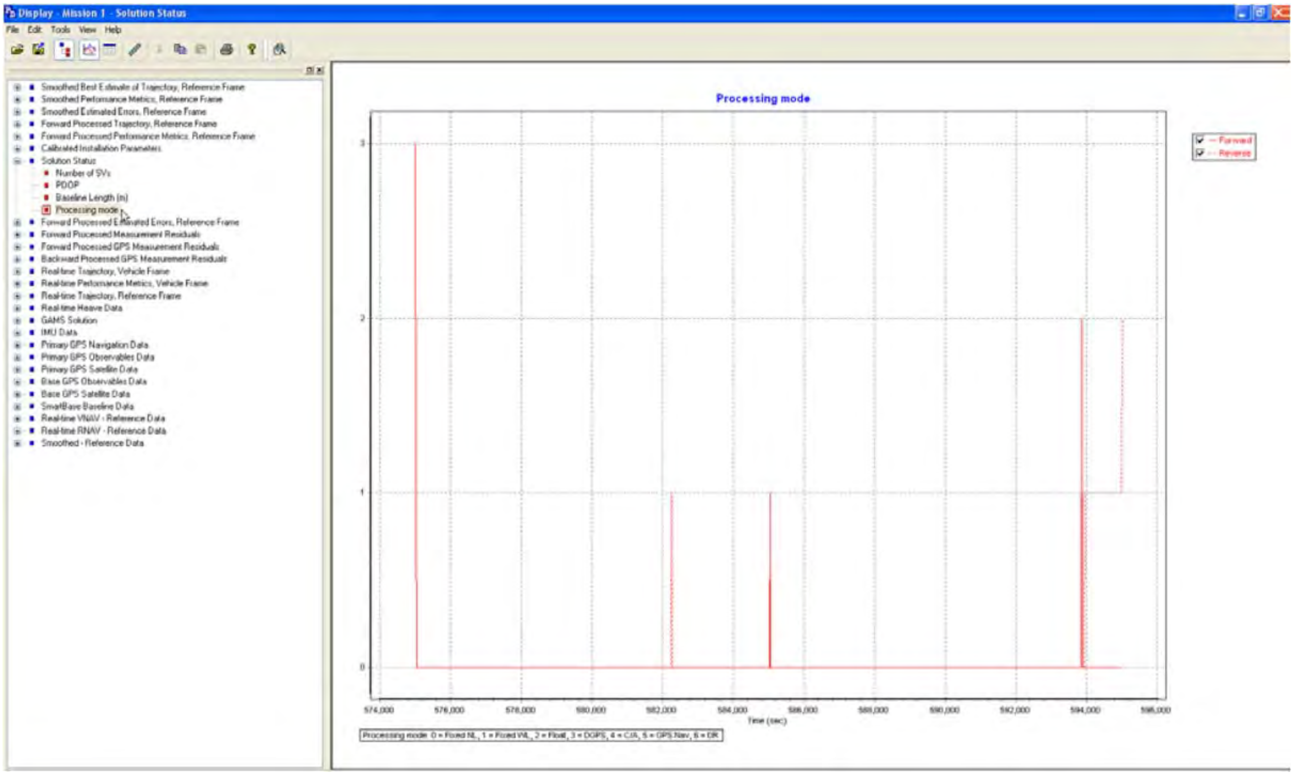
o **Number of SV's.** Found under "Solution Status" and then Number of SVs. The number of satellites should be five or more. Drops in satellite numbers can be seen in the RMS error data.



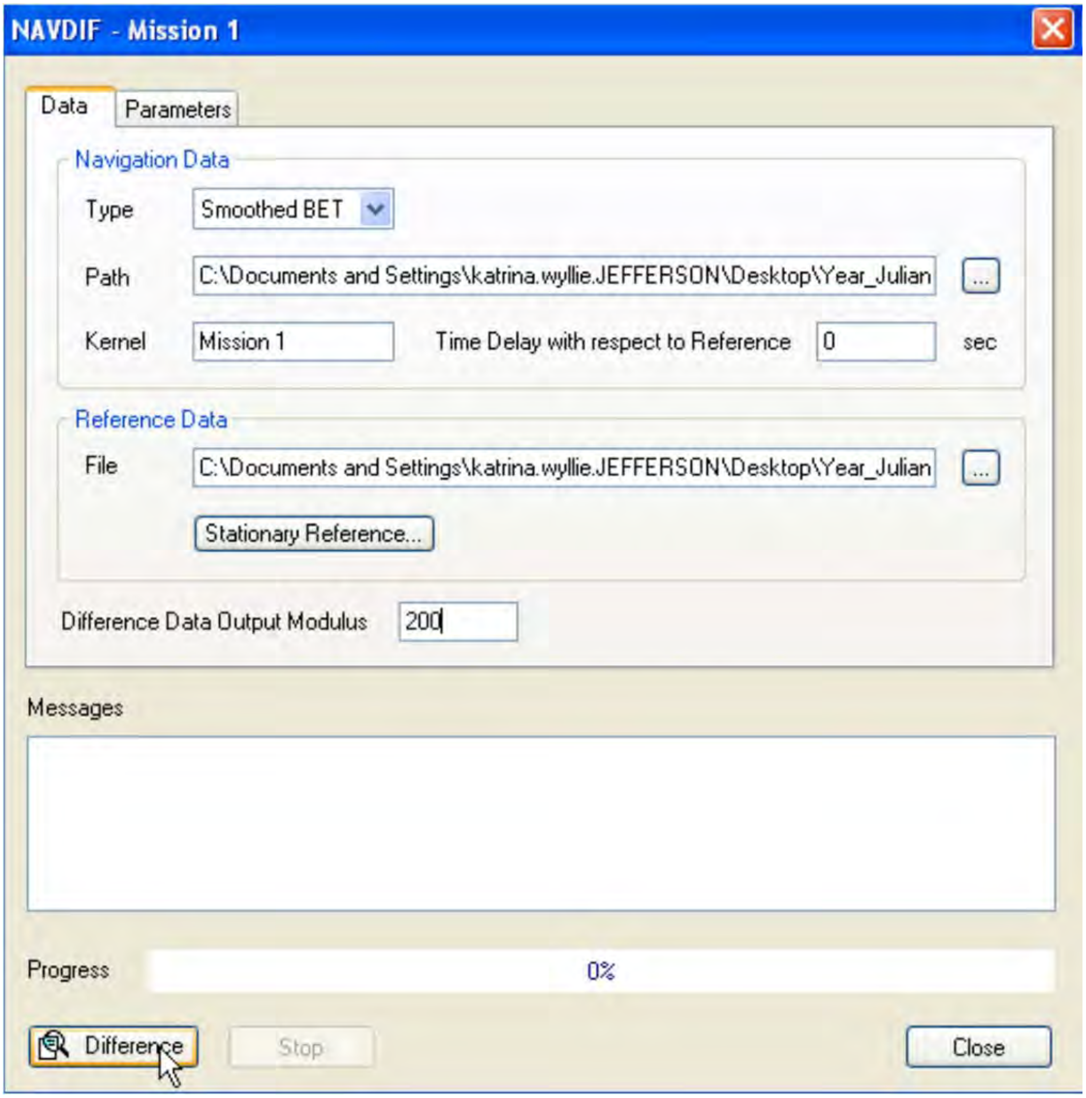
o **PDOP.** Found under “Solution Status” and then PDOP. The PDOP values are usually below 3. The FPM has guidelines to keep this number below 6. When PDOP goes above three, there is correlation in RMS error jumps.



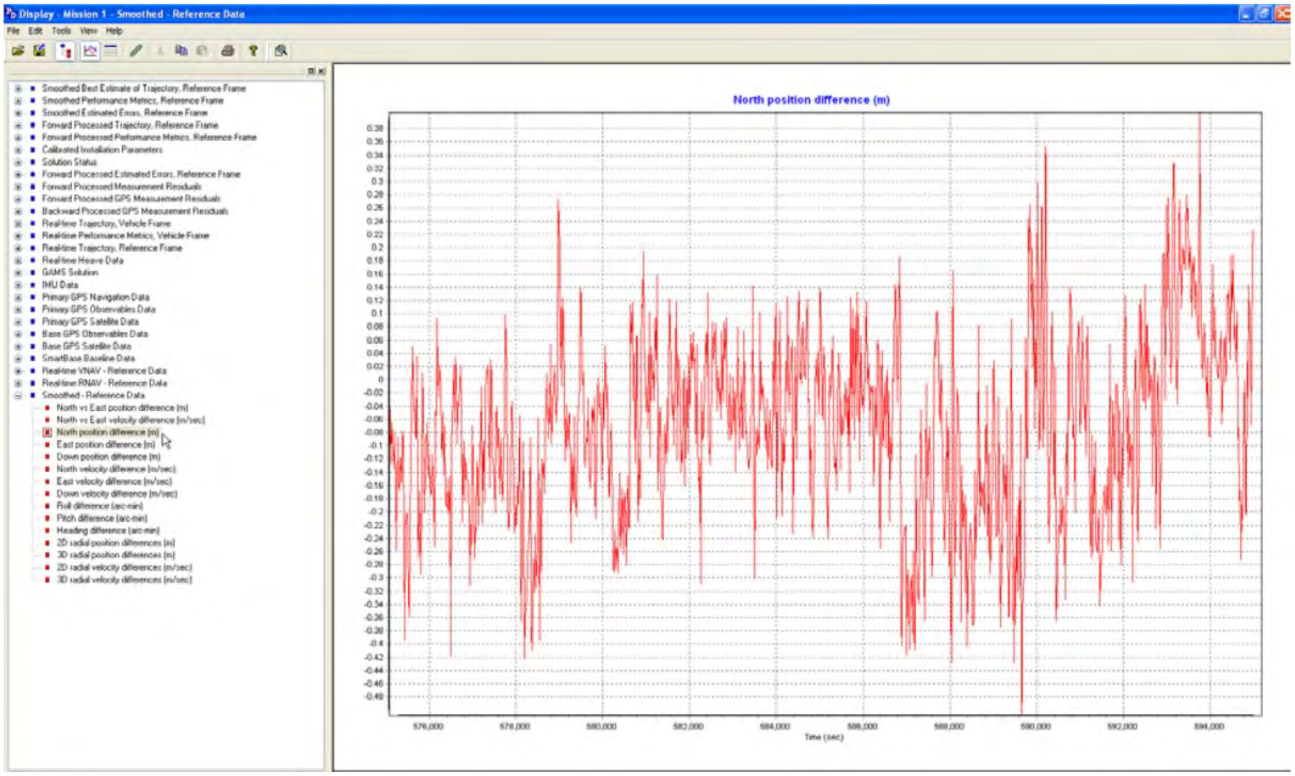
o **Processing mode.** Found under "Solution Status" and then Processing mode. There is a key below this plot that identifies the numerical value of the processing mode. The best solution would be a 0, or Fixed NL. Record the values in the SBET Check sheet.



o **Smoothed- Reference Data**. First, click on Tools, NAVDIF. Under the Reference Data file, browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Extract folder and select vnav_Mission 1.out. Change the Difference Data Output Modulus to 200. Click Difference.



You are differencing the real-time navigation to the SBET solution. When the difference is done, close the NAVDIF box. A new plot will pop up, called Smoothed- Reference Data. Look at the North, East and Down position difference (m) plots. The min/max values for North and East differences should be within +/- 0.50m. The min/max values for the Down difference should be +/- 1m



Step Eight: Export, Rename SBET and Associated Error File

• Browse to H:\Surveys\HXXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the sbet_Mission 1.out file and rename it to *"Year_JulianDay_Vessel_SBET.out."*

• Browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the smrmsg_Mission 1.out and rename it to *Year_JulianDay_Vessel_RMS.out*

USING POSPAC MMS 5.4 TO PROCESS GPS (SINGLEBASE)

SINGLEBASE BATCH PROCESSING

Open POSPac MMS 5.4 and select Run -> Batch Manager, see figure 1 below.

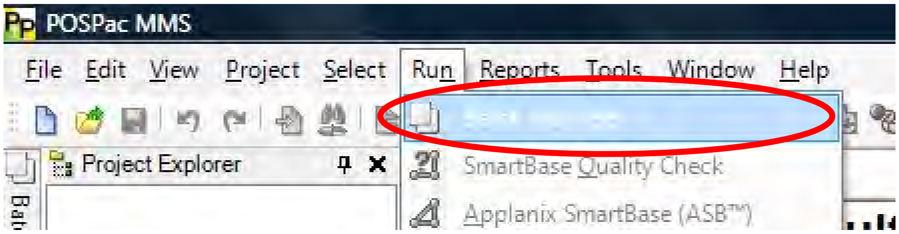


Figure 1

This will bring up the *Batch Manager*. Click the New Batch icon in the upper left corner of the pane, see figure 2 below.

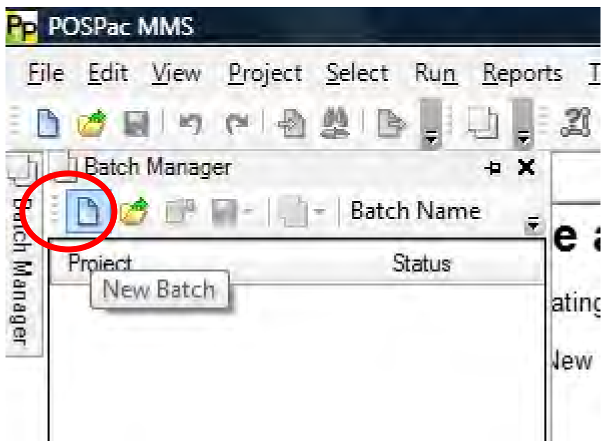


Figure 2

This will bring up the save file dialog for the batch configuration file. Save the batch configuration file to the POSPAC folder in the appropriate project,

W:/Control/HORCON/Projects/YYYY/OPR-XXXX-FA-YY/POSPAC/HXXXXX
(i.e. W:/Control/HORCON/Projects/2009/OPR-O119-FA-09/POSPAC/H12345)

Use the naming convention sheetnumber_daynumber as in “**HXXXXX_DDD.posbat**” (i.e. H12072_172.posbat) for the batch configuration file.

After saving the batch configuration file the batch editor dialog will come up, see figure 3. Enter the POSPac project name, of which there is one for each POSPac (true heave) file. Use the name "**YYYY_DDD_VVVV**" where YYYY is the year, DDD is the day number, and VVVV is the vessel. On the *POS Data Location* tab use the open file button to the right of the *First File* field to navigate to and select the appropriate POS data file for the vessel and day (the *Last File* field will auto fill with the same file name and only needs to be explicitly set if multiple POS data files were logged in immediate succession). POSPac files are stored under I:\YYYY_Processed_Data\GNSS_DATA\OPR_XXXX_FA_YY\POSMV_Data\HXXXXX under the boat day folder as .000 files. ***DON'T USE ANY .000.FIXED FILES- USE THE RAW POSPAC FILE OTHERWISE YOU WILL HAVE PROBLEMS!***

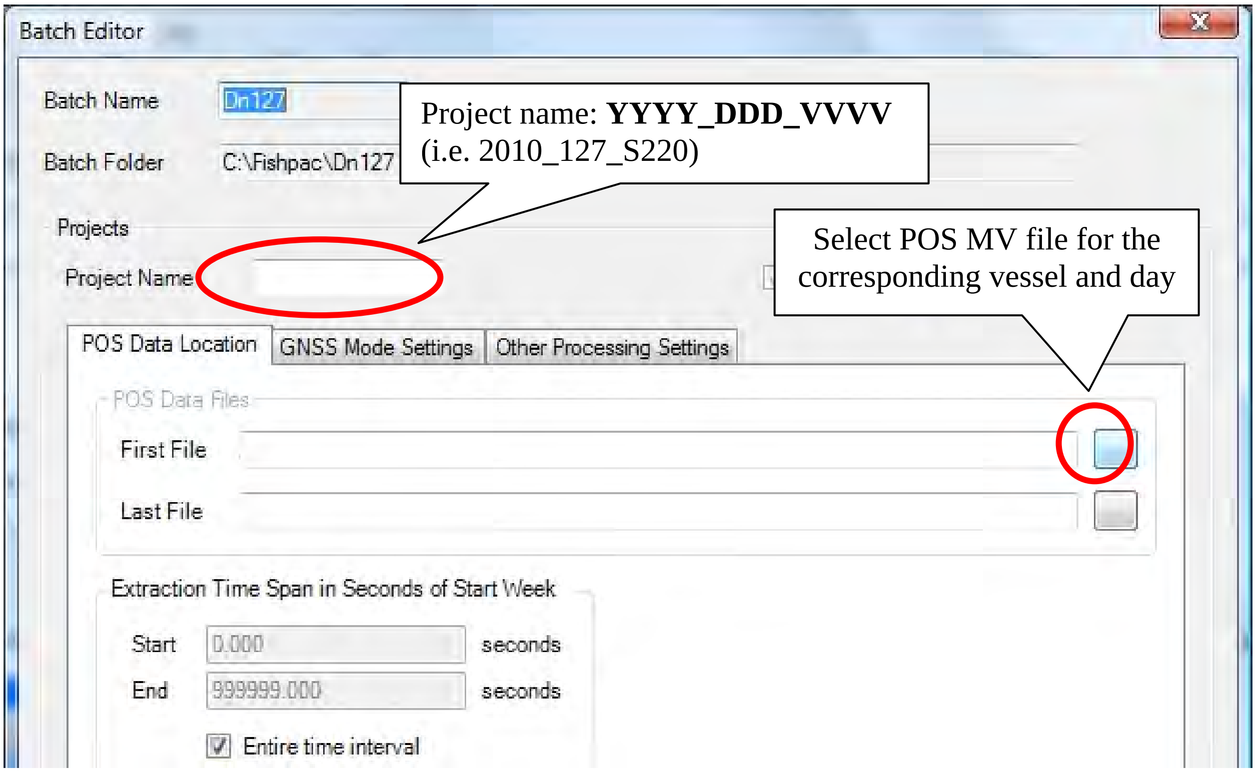


Figure 3

Next select the *GNSS Mode Settings* tab, see figure 4 below, and change the GNSS Mode to *Single Base Station*.

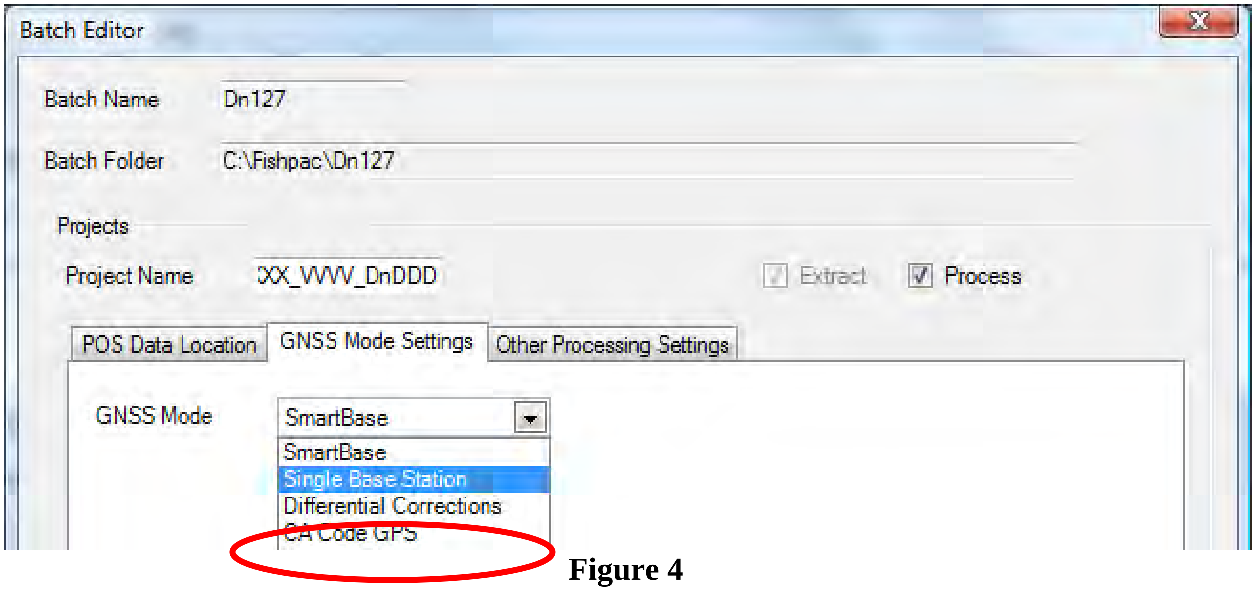


Figure 4

The *Single Base Settings* interface will come up, see figure 5. To the right of the *Base File(s)* field click the button with the ellipse, this will bring up the *Base GNSS File(s)* dialog, see figure 6, click *Add* to navigate to and select the rinex file (*.10o) for the same day as the POS data. This may include two files if data was logged after UTC midnight.
Find the rinex file at I:\2010_Processed_Data\GNSS_DATA\OPR_XXX_FA_10\Base_Station_Data*Base_Station_Name*\SSSSddd0.10o where SSSS is the S/N of the GPS receiver.

NOTE: If you have previously added the control mark to the database click the *Retrieve from DB* button and select the appropriate station from the dialog that opens. Confirm the height of the antenna.

Back on the *GNSS Mode Settings* tab, if this is the first time using the base station on the computer enter the NAD83 (**not** ITRF00) *Latitude*, *Longitude*, *Altitude* (ellipsoid height), and station *Name* from the OPUS solution or NGS datasheet and Enter the *Height* of the antenna from the observation log. This information is located at W:\Control\HorCon\Projects\2010\OPR-O193-FA-10 Behm Canal\POSPAC\HXXXXX_Base_Station.xlsx. After all the data is entered click the *Add to DB* button to save the position for use with future processing.

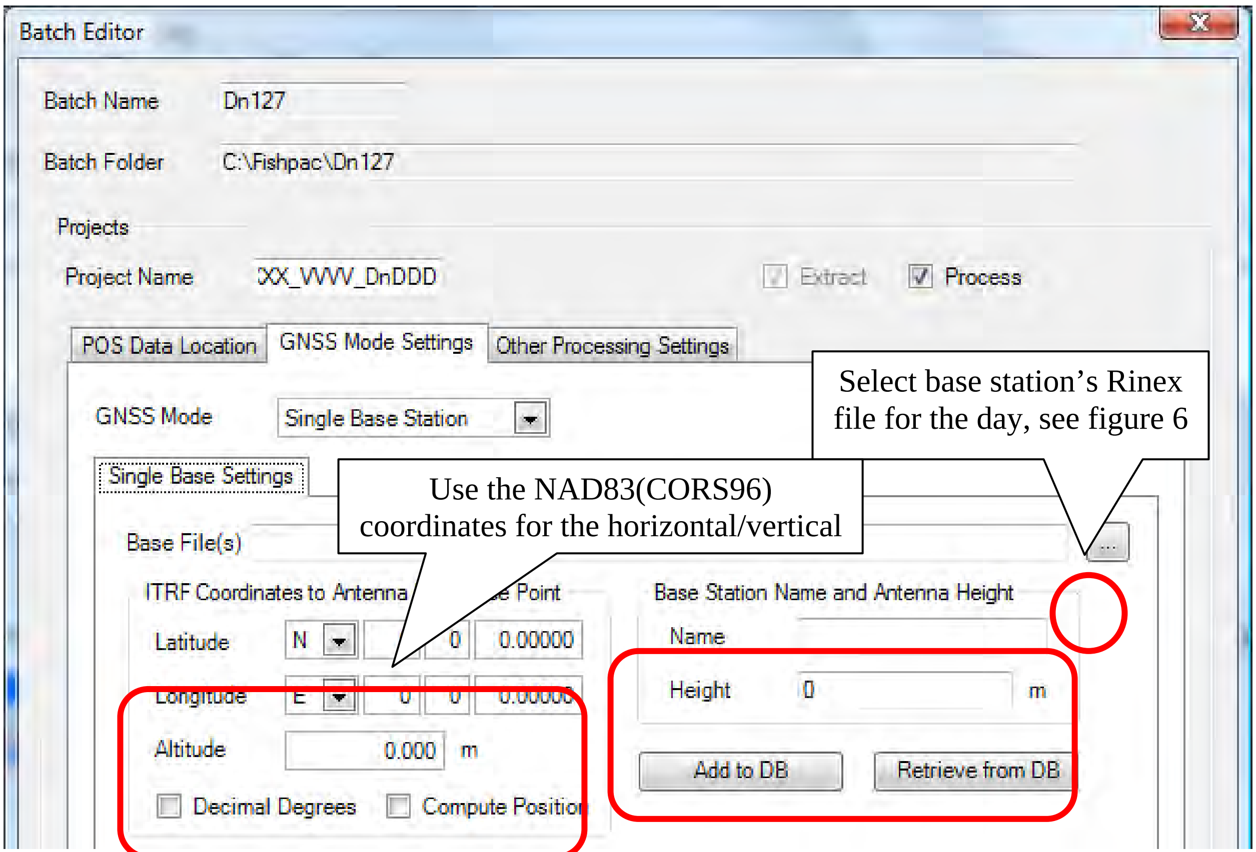


Figure 5

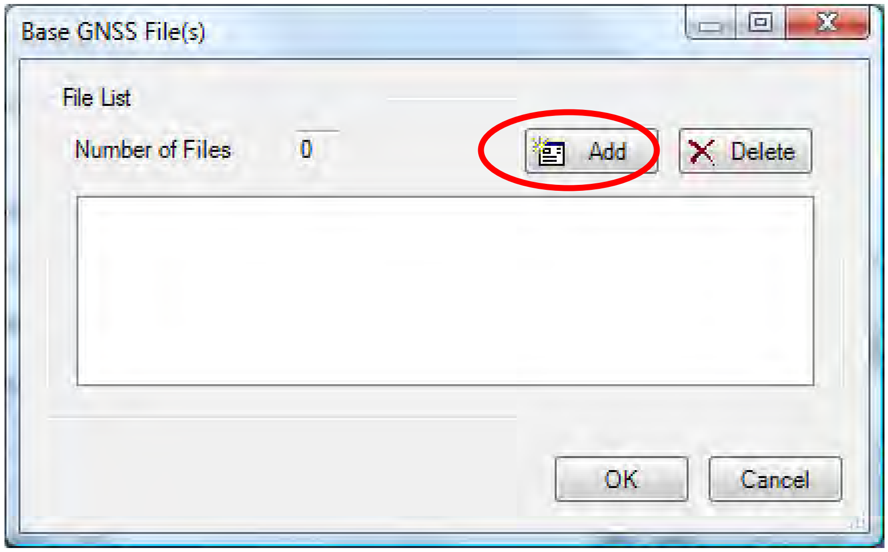


Figure 6

After all the parameters are set you can add the project to the queue. Towards the bottom of the *Batch Editor* dialog click the *Add* button, see figure 7 below, this will add the project to the processing queue.

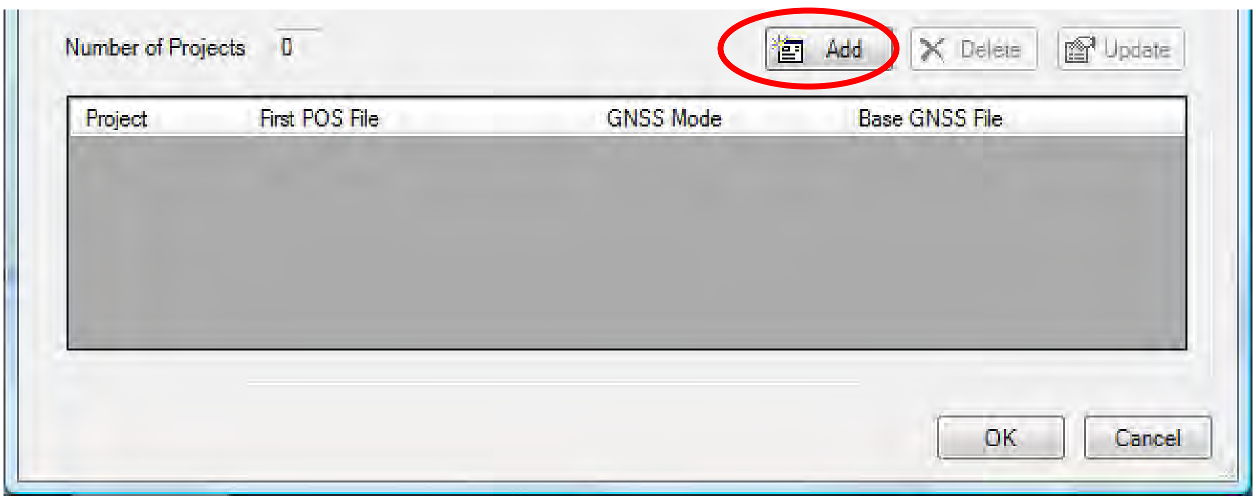


Figure 7

After the project has been added to the queue all the fields in the *Batch Editor* will stay unchanged. Return to the *POS Data Location* tab seen in figure 3. For each POS data file from the same day for other vessels update the *Project Name* and select the appropriate POS data file in the *First File* field and click *Add* towards the bottom of the window.

After all projects have been added to the queue click *OK*.

Back in the main window the *Batch Manager* pane will update with a list of the projects that you added to the queue and the various tasks that will be performed for each project, see figure 8. Select the Run Batch button, see below.

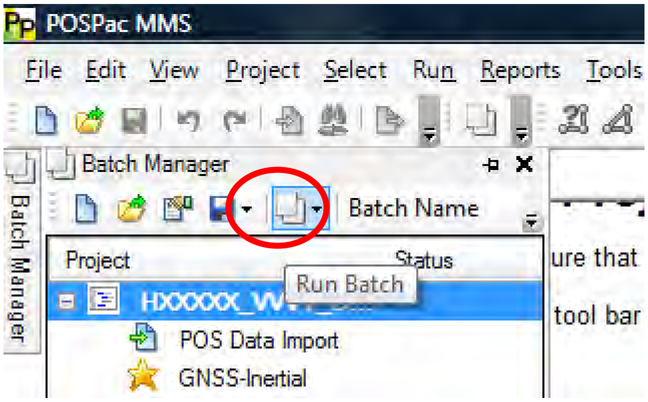


Figure 8

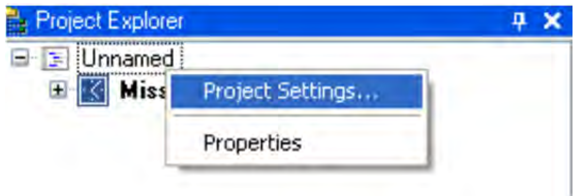
This will start the processing of all the projects in the queue, come back later to check that they all successful completed.

USING POSPAC MMS 5.4 TO PROCESS GPS (SMARTBASE)

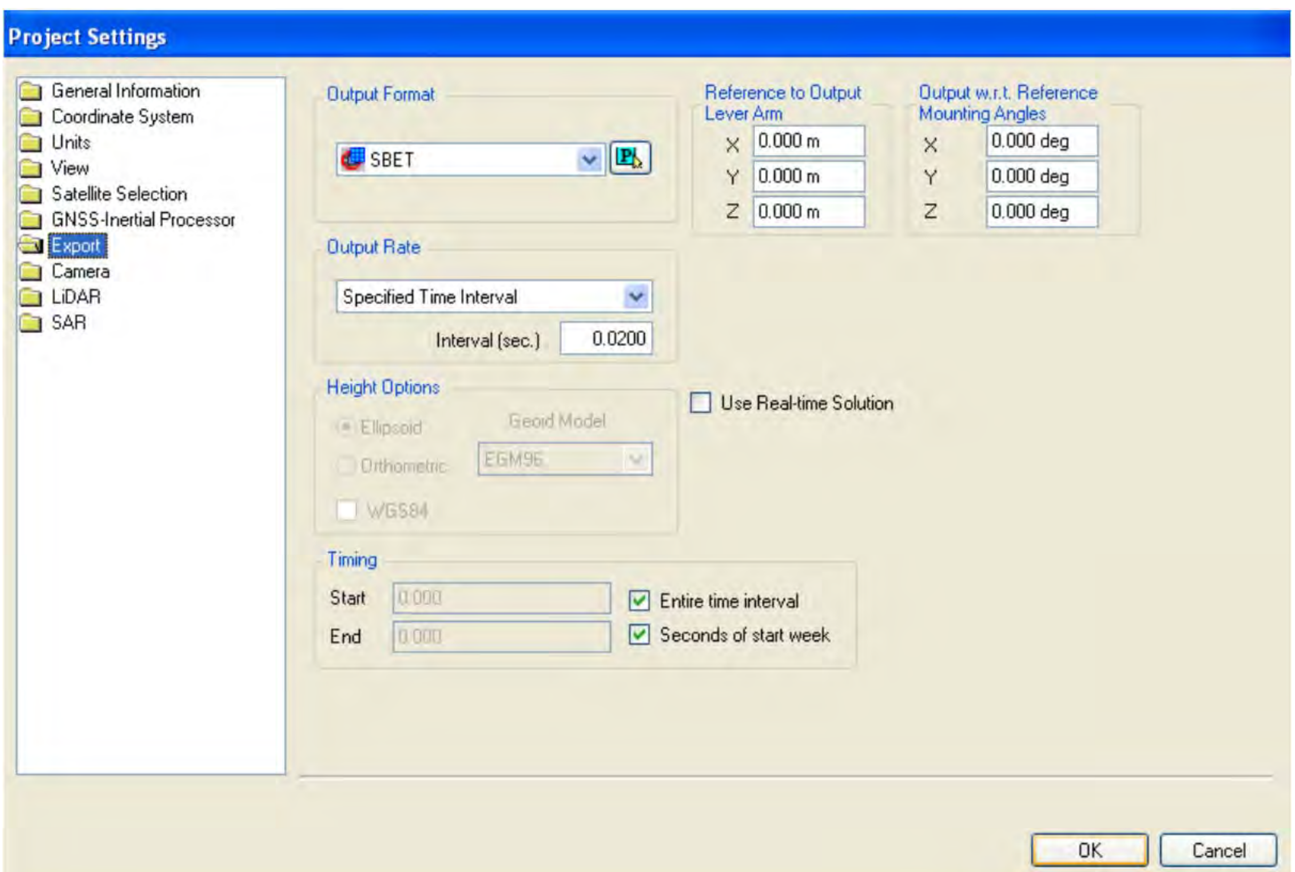
SMARTBASE STANDARD PROCESSING

Step One: Create POSPac MMS 5.4 Template

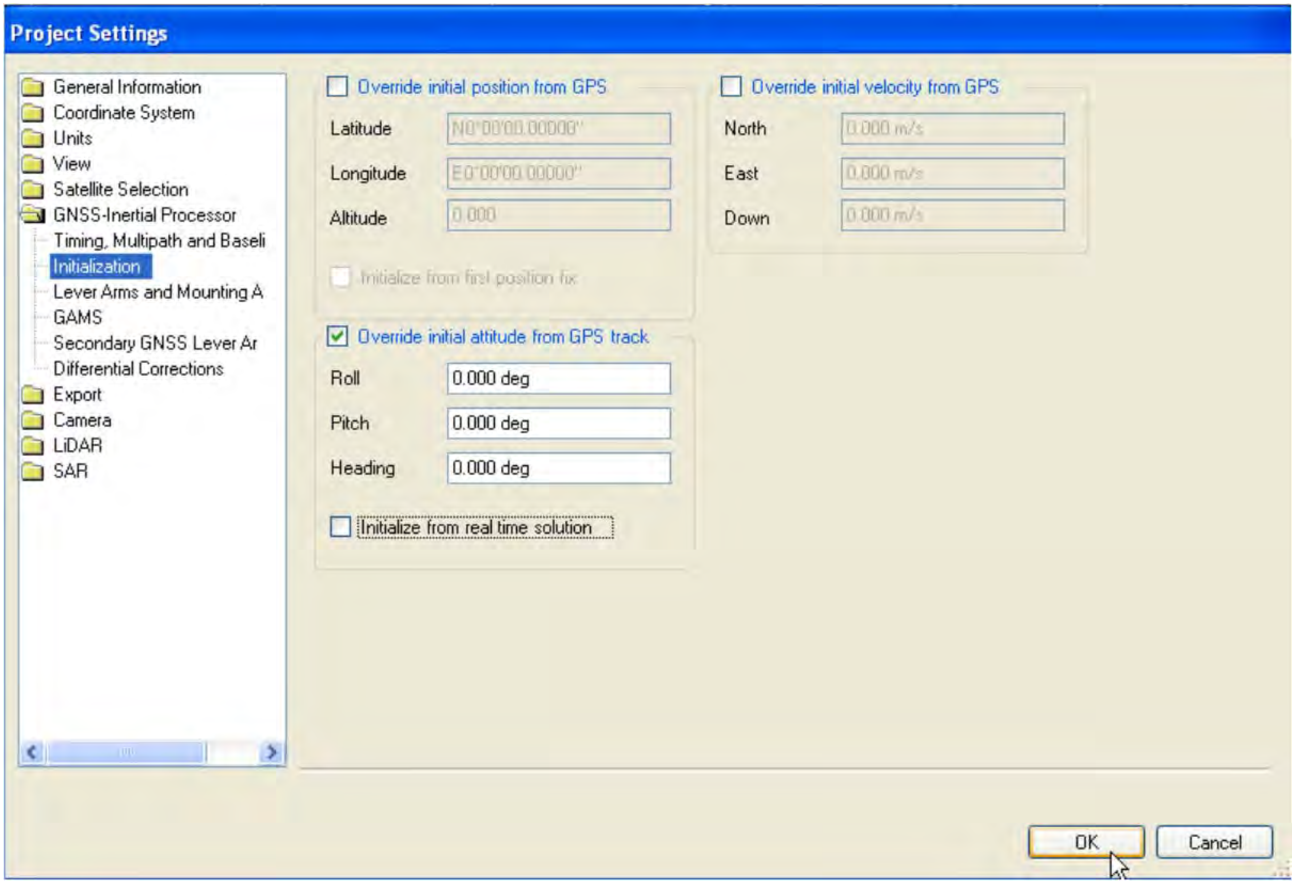
• File, New Project, double click on <Blank Template>
• Under Project Explorer, right mouse click on Unnamed and select Project settings



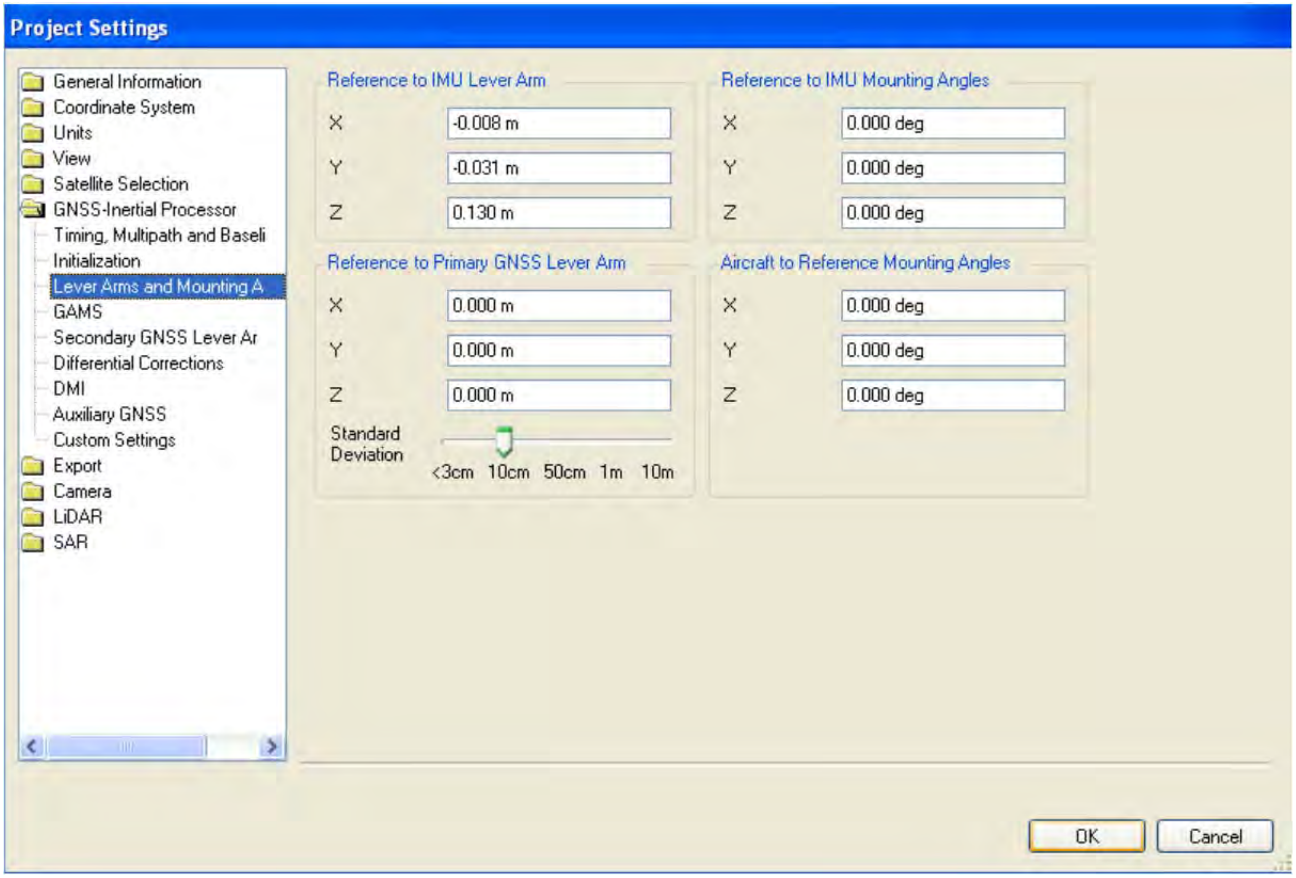
• Navigate to the export tab and change the output format to "SBET" with an output rate "specified time interval" of 0.02 seconds. Unclick "Use Real-Time solution" box.



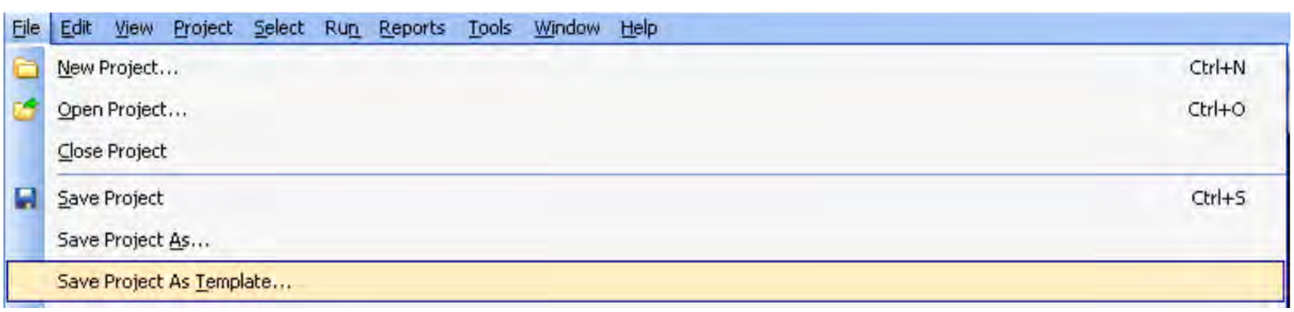
• Navigate to the Initialization tab and ensure the Initialize from real time solution box is *unchecked*



• Navigate to the Lever Arms and Mounting Angles tab and enter Reference to IMU Lever Arm values as shown (-0.008, -0.031,and 0.130):



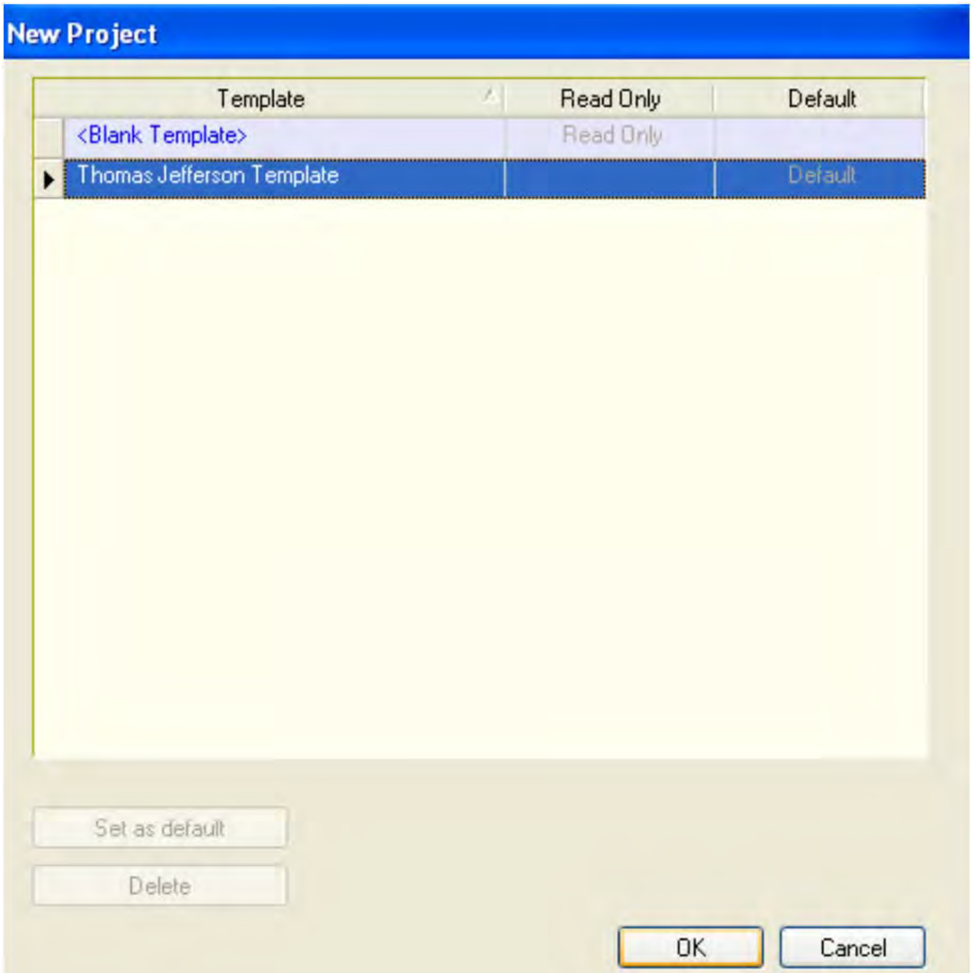
• File, Save Project As Template



• Name the template *NOAA_SHIP_Template* and click the set as default button, then ok

Step Two: Create a POSPac 5.4 Project:

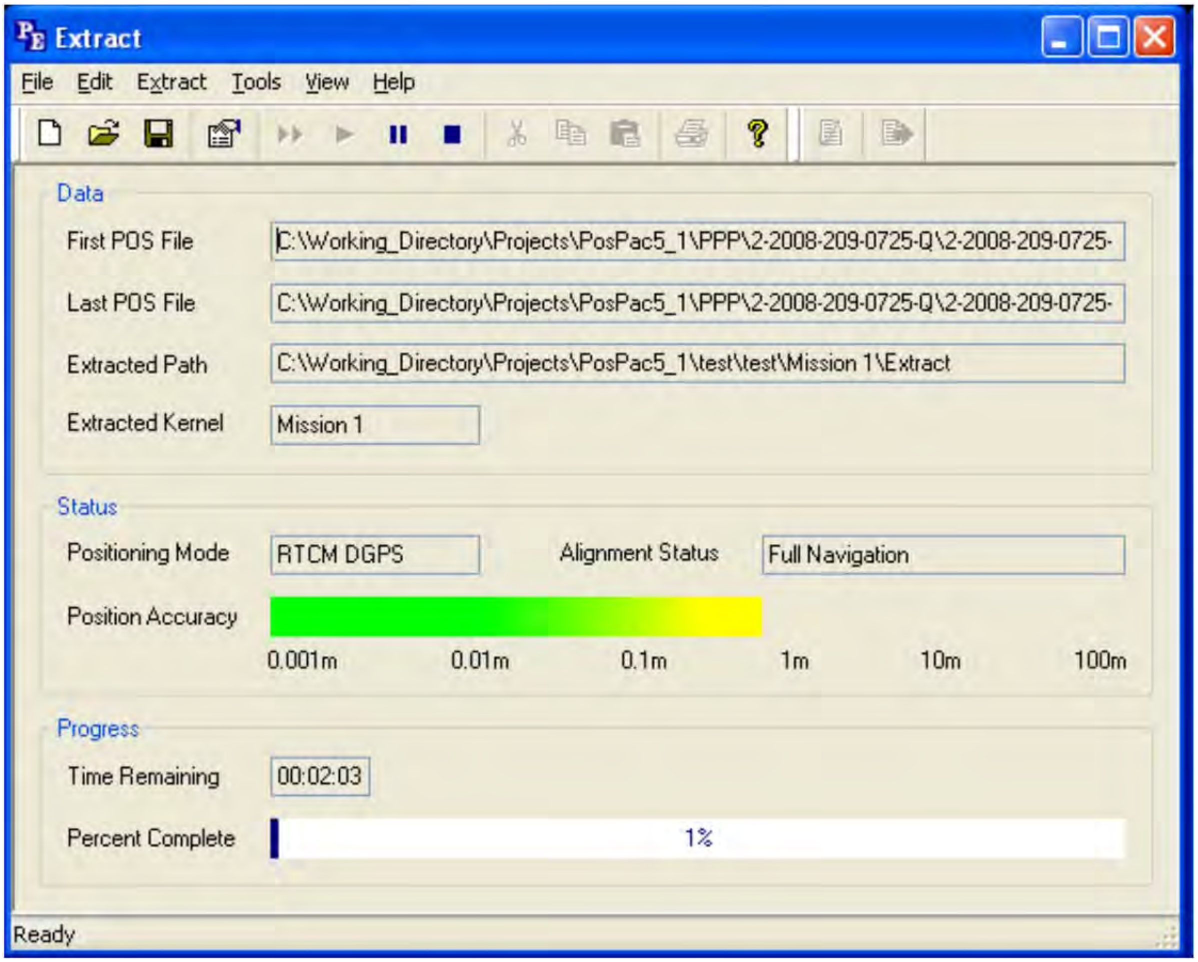
• File, New project. Highlight the template created in Step One and click OK



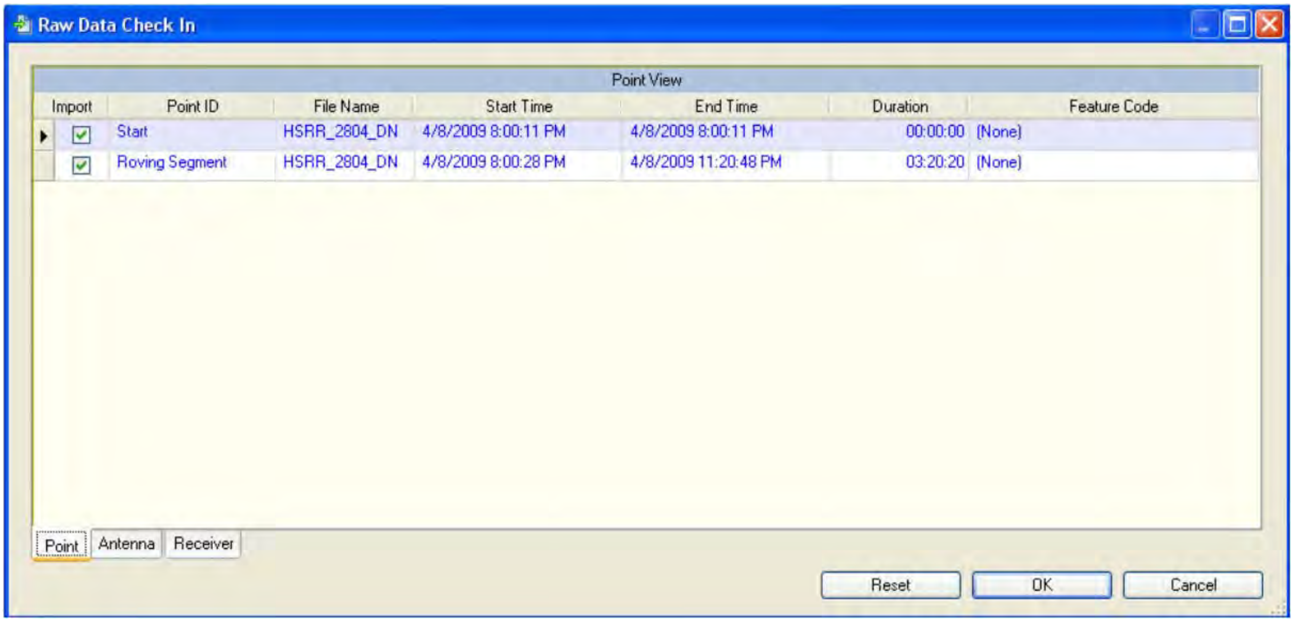
• File, Save Project. Save as *Year_JulianDay_Vessel*

Step Three: Import the Raw POS

• Open a windows explorer window and locate the POSPac file(s) for the specific project, vessel and day. **Drag and Drop your .000 file into the Plan View window**



• Say OK at the following window. Antenna and Receiver should remain unknown for the POS data.



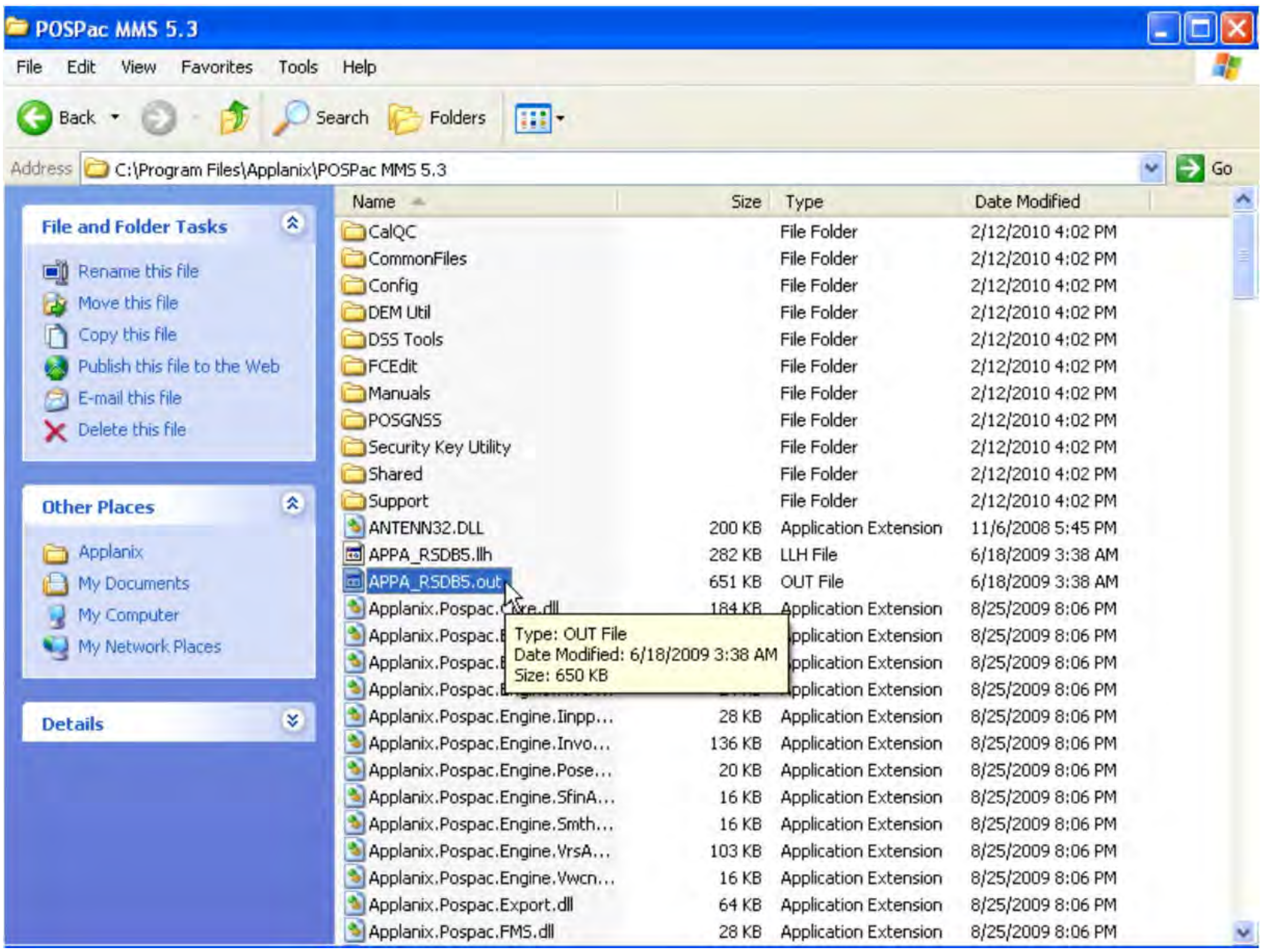
• The project definition can remain unchanged. Simply select "OK"

Step Four: Download multiple base and ephemeris data

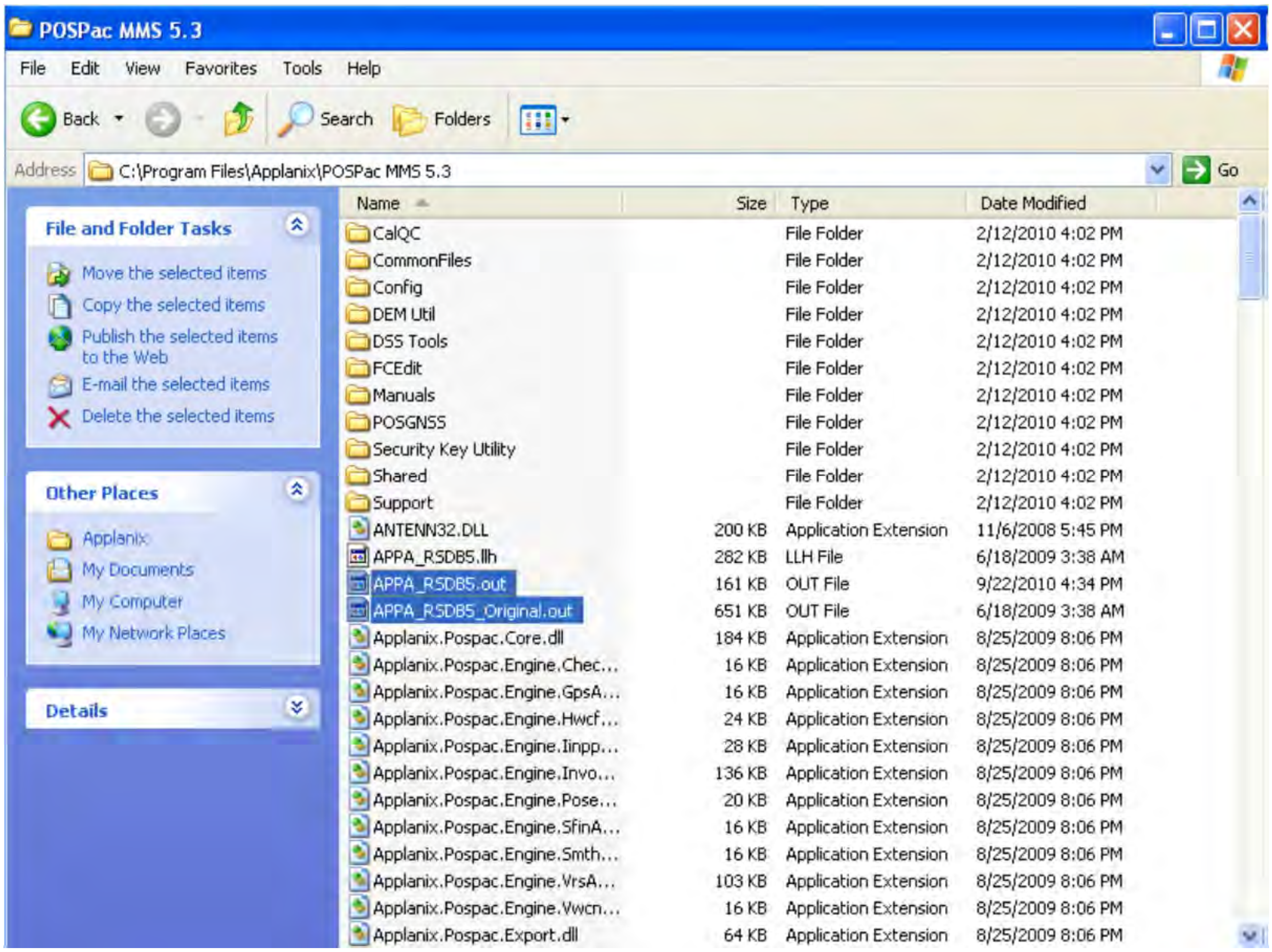
• Load appropriate APPA_RSDB5.out file for specific project.

o Browse to H:\Surveys\HXXXXX\CARIS\SBET folder and locate APPA_RSDB5.out. This file has been modified to include a specific selection of base stations for this project.

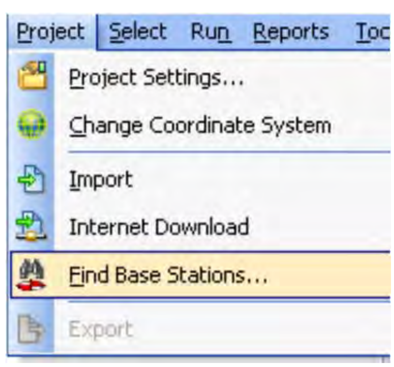
o Browse to C:\Program Files\Applanix\POSPac MMS 5.4. In this folder, there will be an existing APPA_RSDB5.out file that includes base stations for the entire United States. Rename this file to APPA_RSDb5_Original.out so this information is not lost.



o Copy and paste the APPA_RSDB5.out file from H:\Surveys\HXXXXX\CARIS\SBET folder into the C:\Program Files\Applanix\POSPac folder. You should have both an APPA_RSDB5_Original.out and an APPA_RSDB5.out file. POSPac will only read from the APPA_RSDB5.out file.



• In POSPac, *Project > Find Base Stations*,

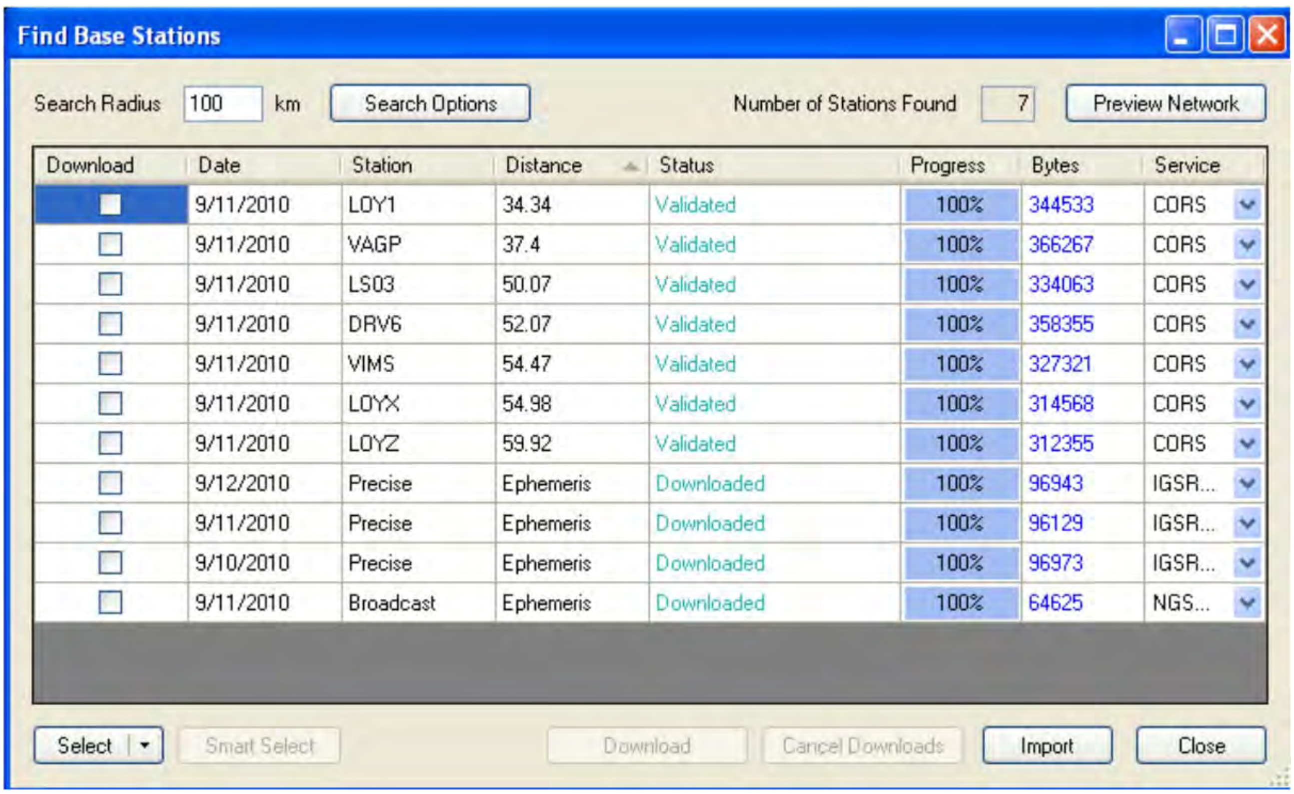


• Enter a search radius of 100 km (can be extended if necessary but want to avoid using stations too far away)

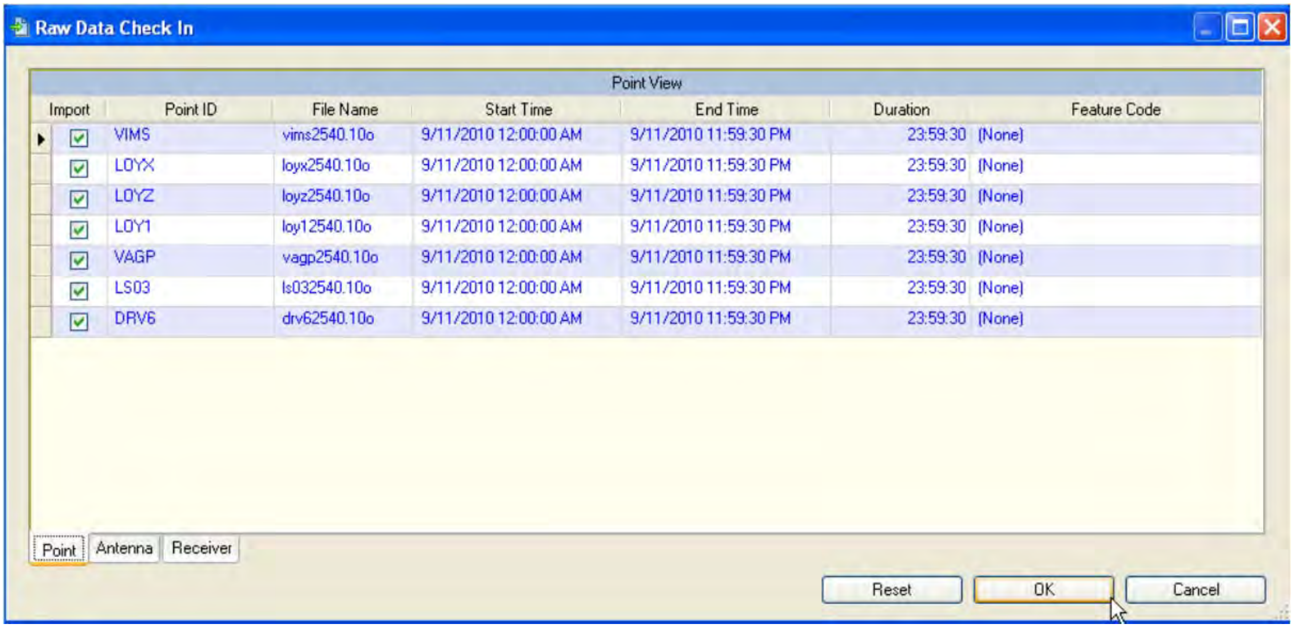
• Select *Preview Network* and all stations within the search radius will be plotted in relation to the POSPac Plan View. A minimum of **four** base stations is required for smart base processing.

• Select all ephemeris files (broadcast and precise) listed. If the POS data spans multiple Julian days then two files for each base will be listed – select both.

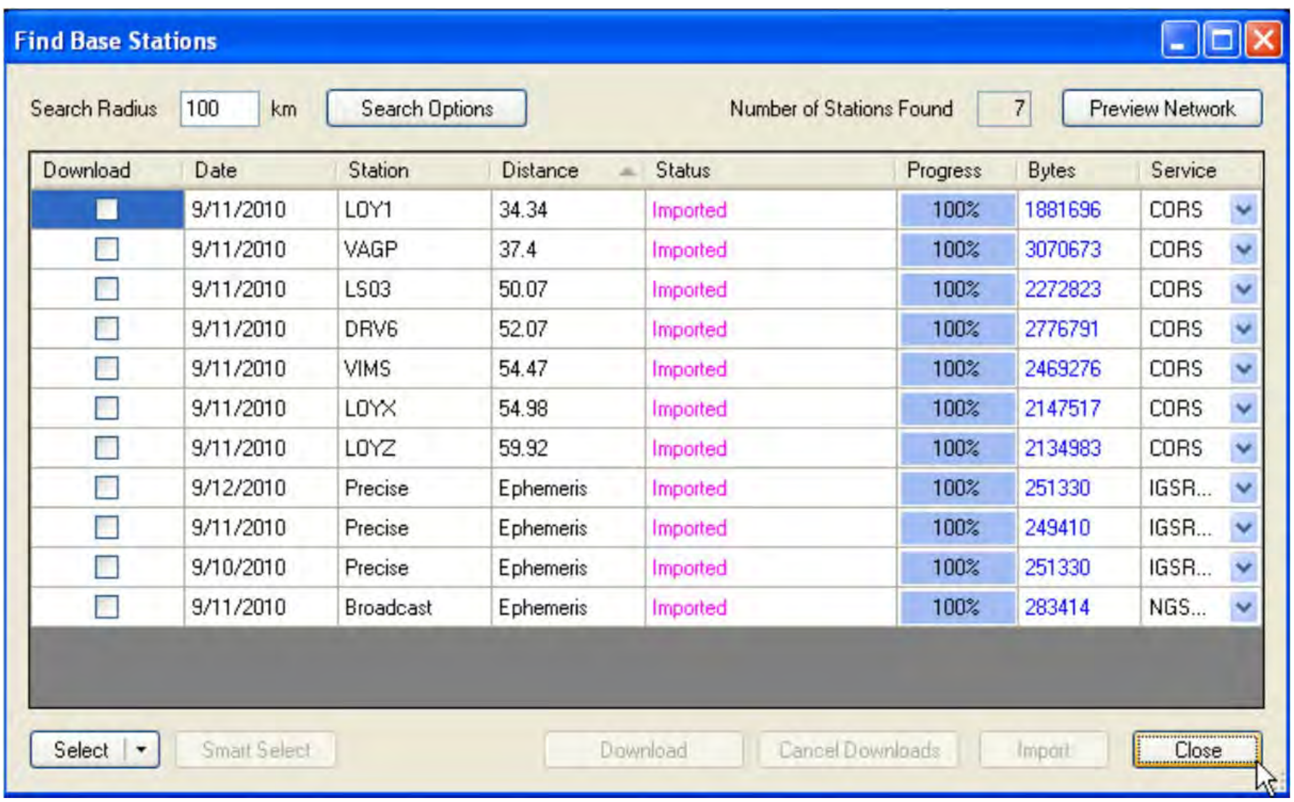
• Select *Download*. Some stations might be unavailable; try downloading them again. If still unavailable then choose another site that can take its place in the network.



• Select *Import.* Raw Data Check in will appear, select OK

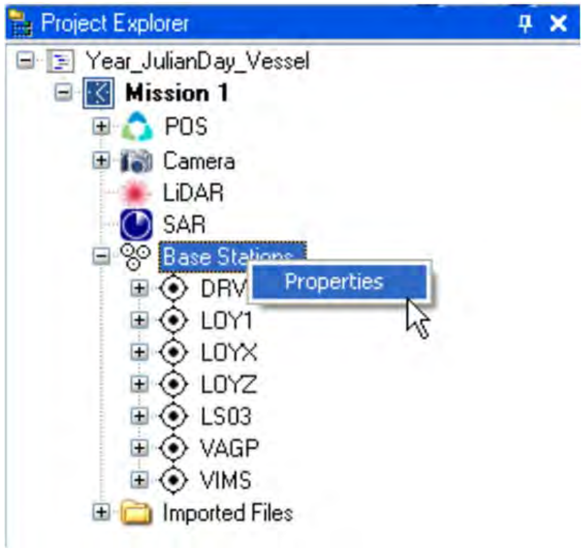


• When satisfied with the network, close the Find Base Station dialogue.



Step Five: Ensure base station coordinates are NAD83, not ITRF00

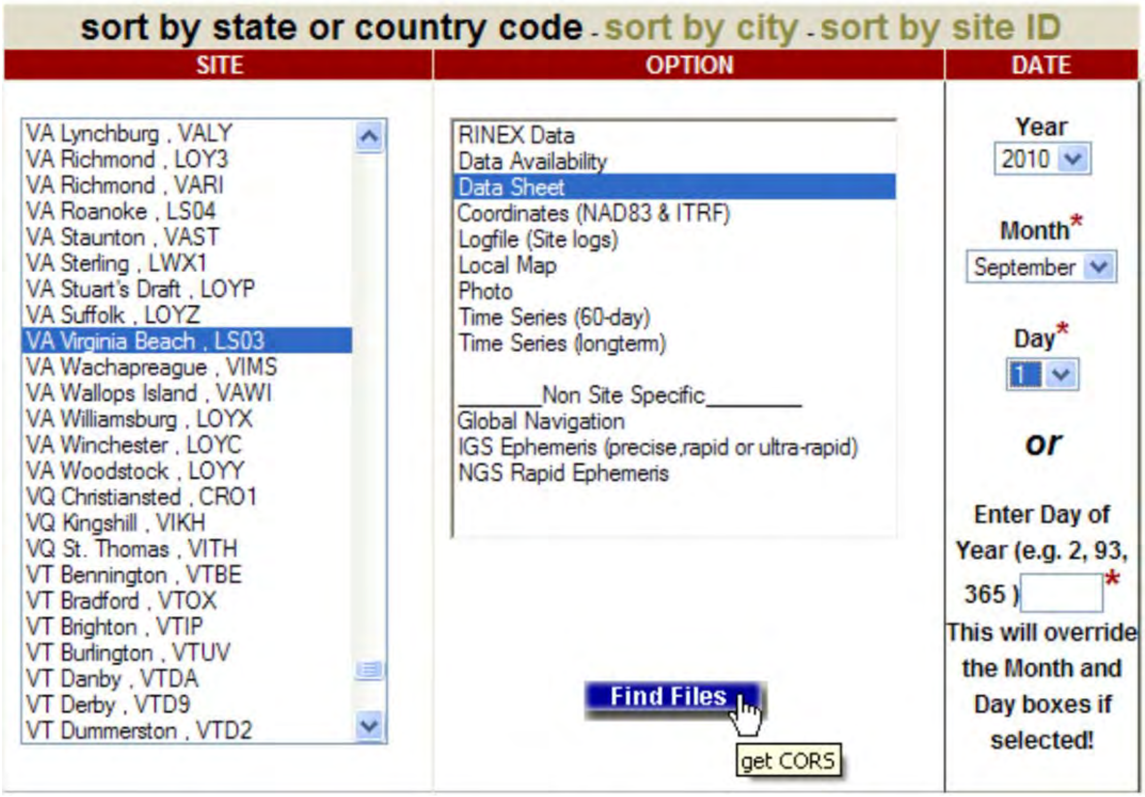
• In Project Explorer pane, under Base Stations, right click and select Properties



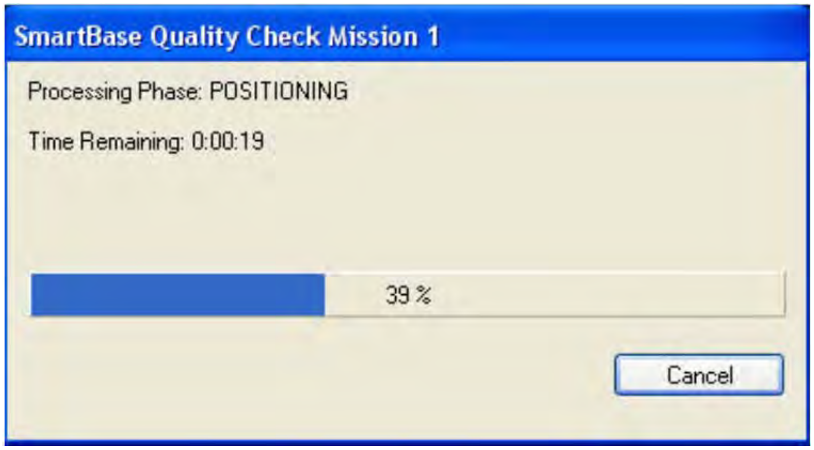
• Compare the locations of each base station to those provided in the project instructions (NAD83 values)

• If the project instructions do not include a base station you have downloaded, you can use the published NAD83 position from the CORS datasheet to confirm the correct NAD83 coordinates.

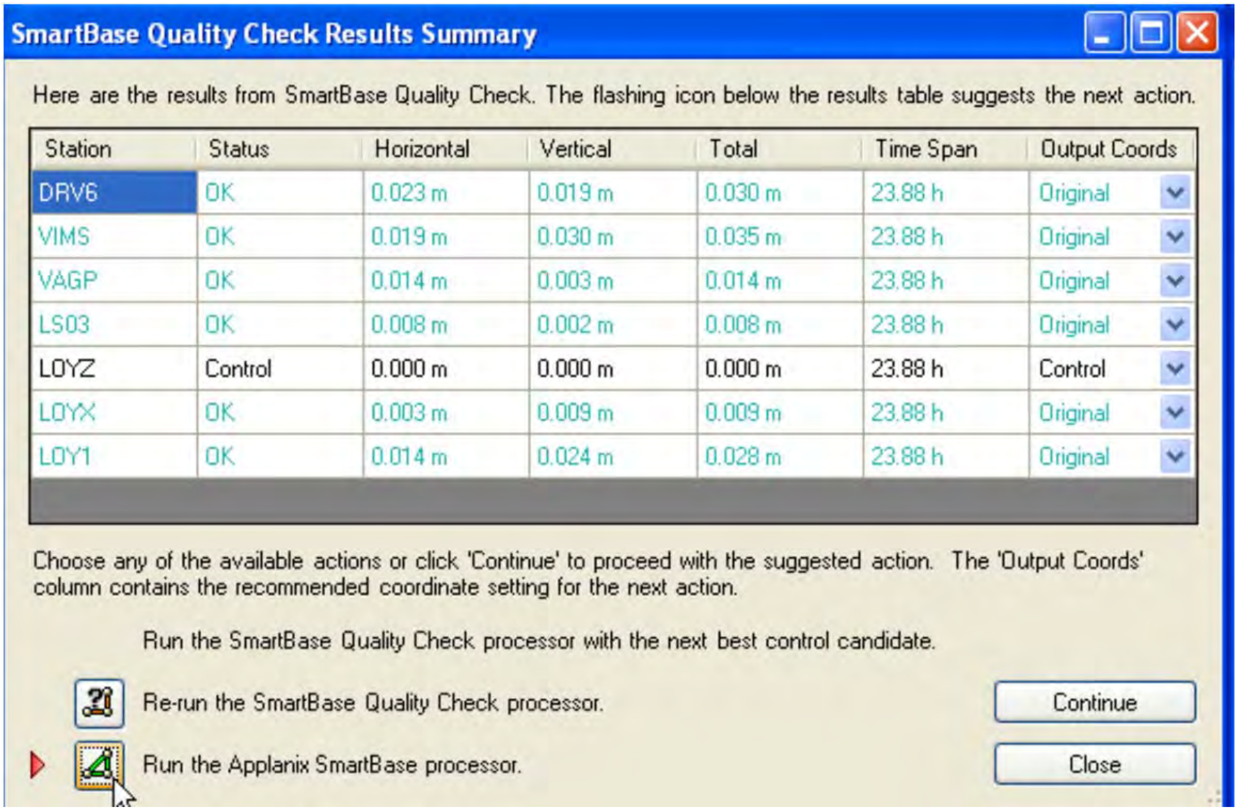
o CORS: http://www.ngs.noaa.gov/CORS/standard1.shtml



• After confirming the correct locations, Select *Run* > *SmartBase Quality Check*. The Quality Check Summary will appear.



• Bad or adjusted positions will be highlighted in red or blue. Do not blindly accept adjusted positions without investigating in coordinate manager. The control station is defaulted to the closest station, if there are adjusted positions listed, change the control station to the next closest station and re-run the SmartBase Quality Check processor (do not accept the adjusted positions). It is also possible to disable a station with a bad position but only if there is another one to take its place in the network.

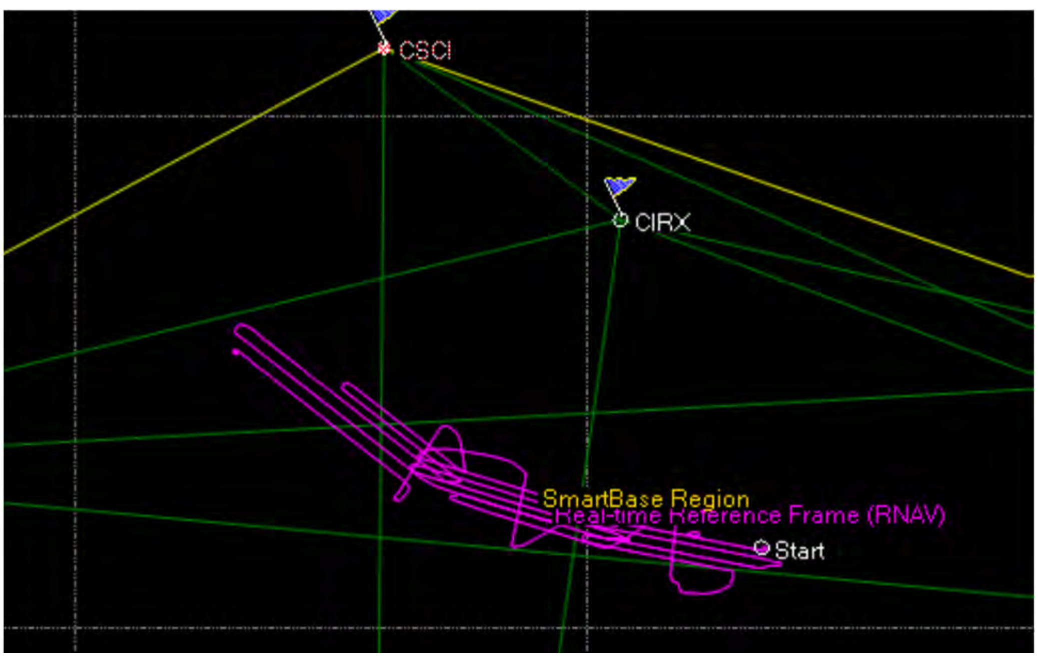


• Select "Run the Applanix SmartBase processor" button that has a flashing red triangle to the left.

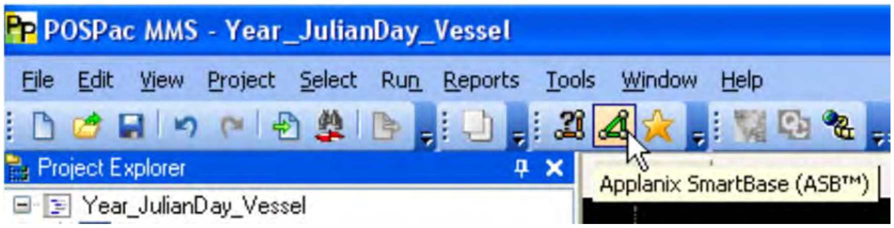
o If no errors appear, the network was successfully created and a yellow line will surround the SmartBase network. Proceed to next step o If any error logs appear, it is usually because ASB was not satisfied with the Primary base station either because of gaps or cycle slips. Open the message log and scroll to the Applanix SmartBase (ASB) Processing log

o Look for "Total full data gaps" over 30 seconds for the primary base station. The Primary base can be chosen manually. Select another nearby station from the Base Stations list (preferably one with a 15 second data rate or better.) Right-click on it and select *Set Primary.*

o There will now be another station flagged in the plan view (if a site other then Control was chosen). One is the Control and one is the Primary.



o Run the Applanix SmartBase Processor again. There may be a warning that the user-selected primary is not the closest base; ignore it and select NO.

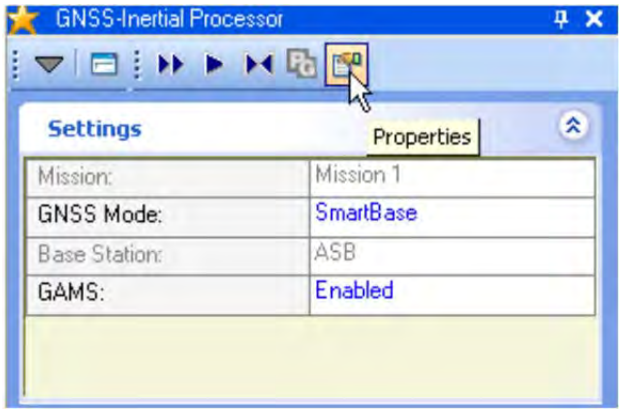


o If no errors occur, the virtual reference station is generated and GNSS Processing can occur.

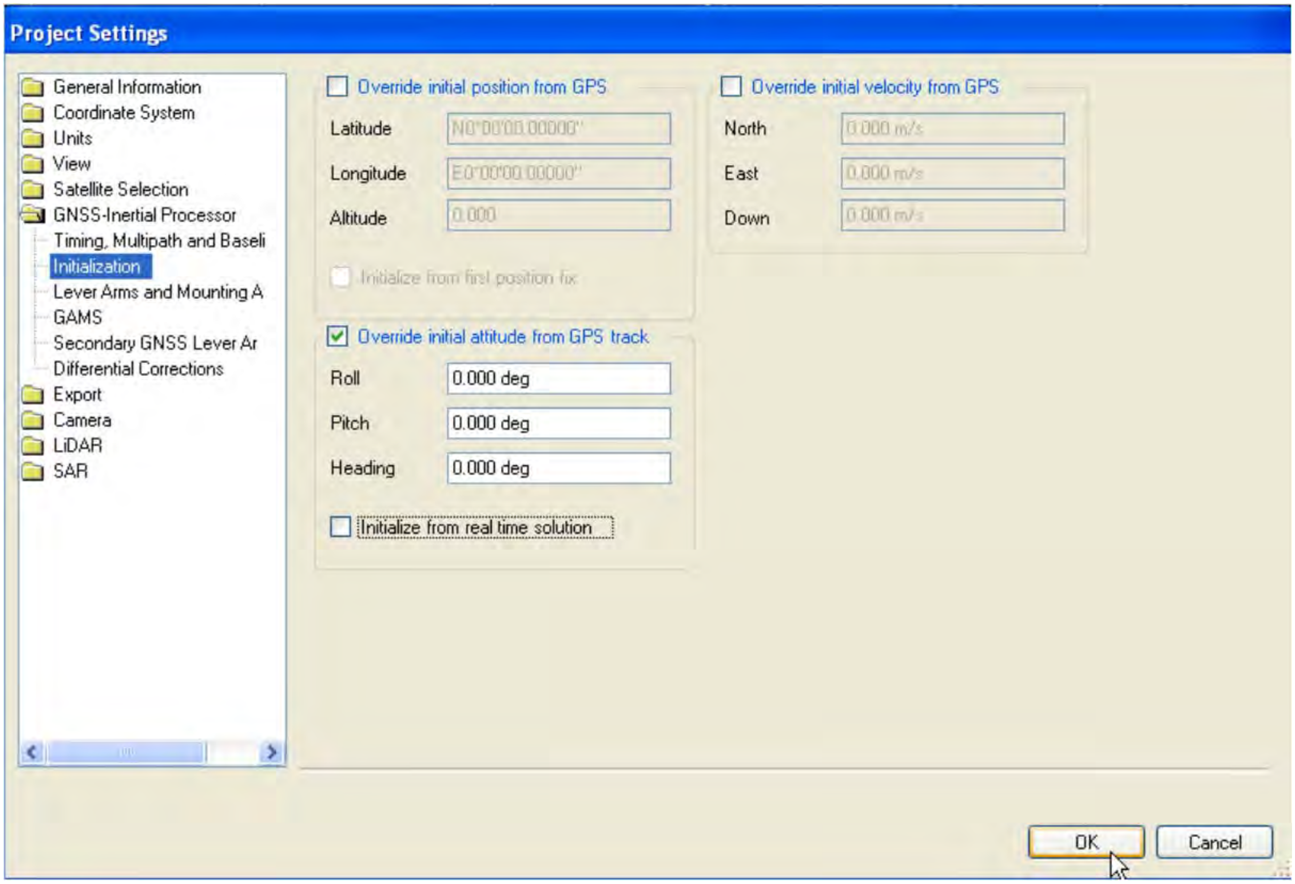
Step Six: GNSS Processor

• From the toolbar select the yellow star, GNSS-Inertial Processor

• Ensure the GNSS mode is SmartBase. Click on the properties icon



• In the Initialization tab, ensure the “initialize from real time solution” box is *unchecked* and click OK



• Select Run, or click on the Forward, Backward and Combine icon to run the GNSS-Inertial processor

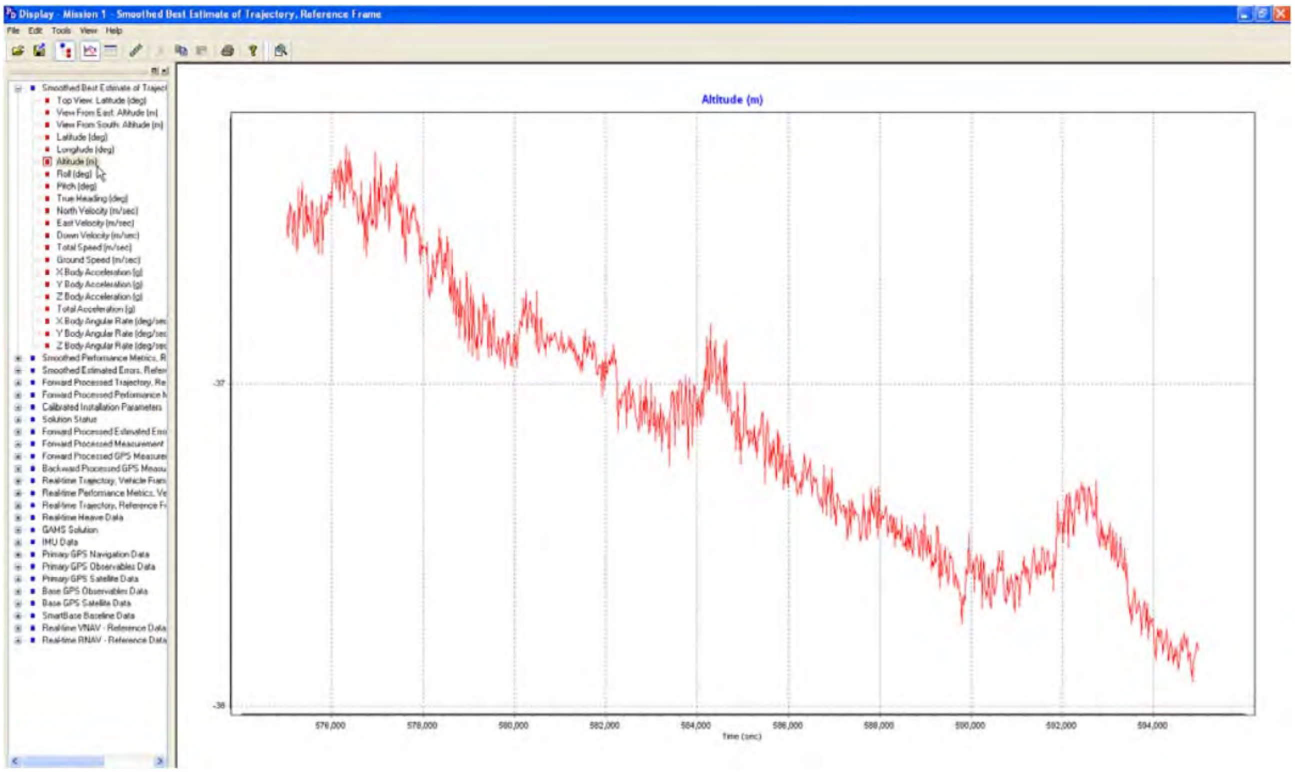
• Close when completed. The track lines should now appear green representing the data has been corrected with a fixed integer solution.

Step Seven: Quality Control Checks for the SBET

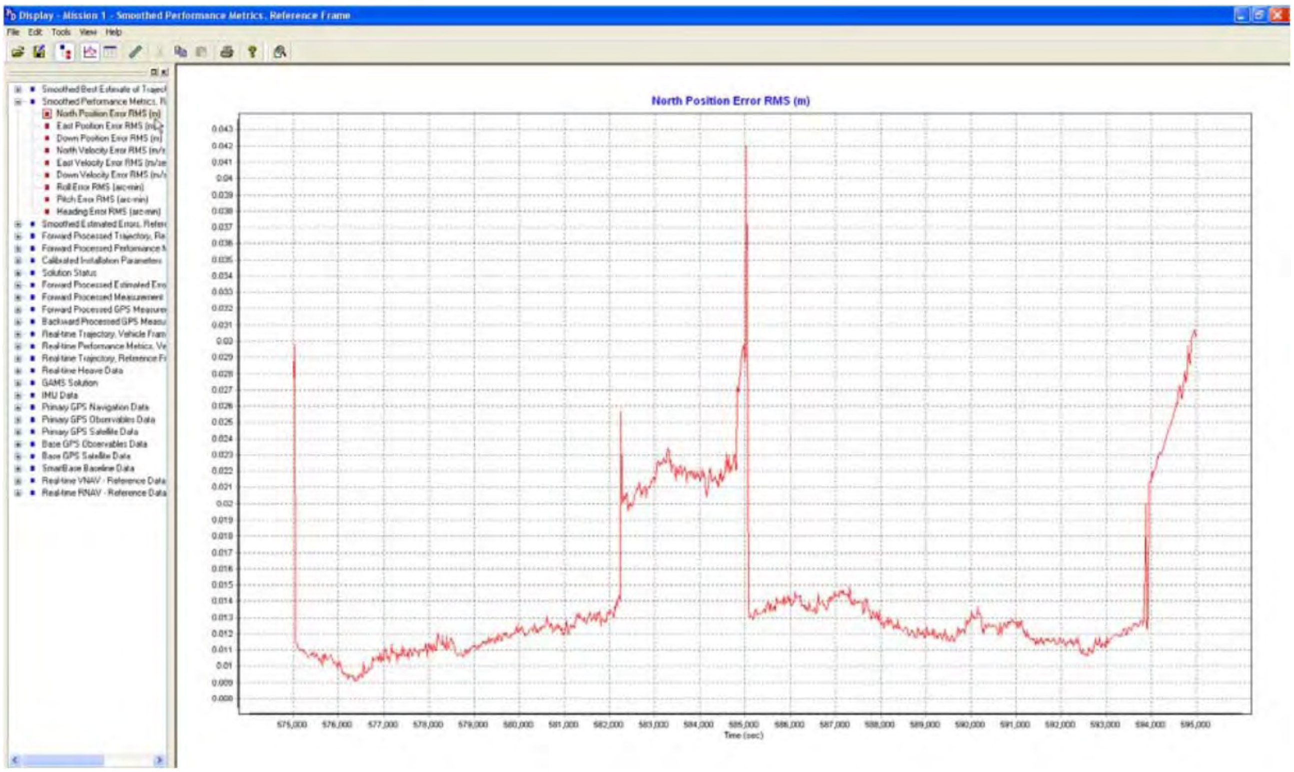
• Examine the message logs for the solution. Look for serious errors, cycle slips and data gaps.

• Examine the plots for the solution. There are multiple ways to examine the data. When examining the data, ensure the HXXXXX_SBET_Checksheet.xlsx is filled out.

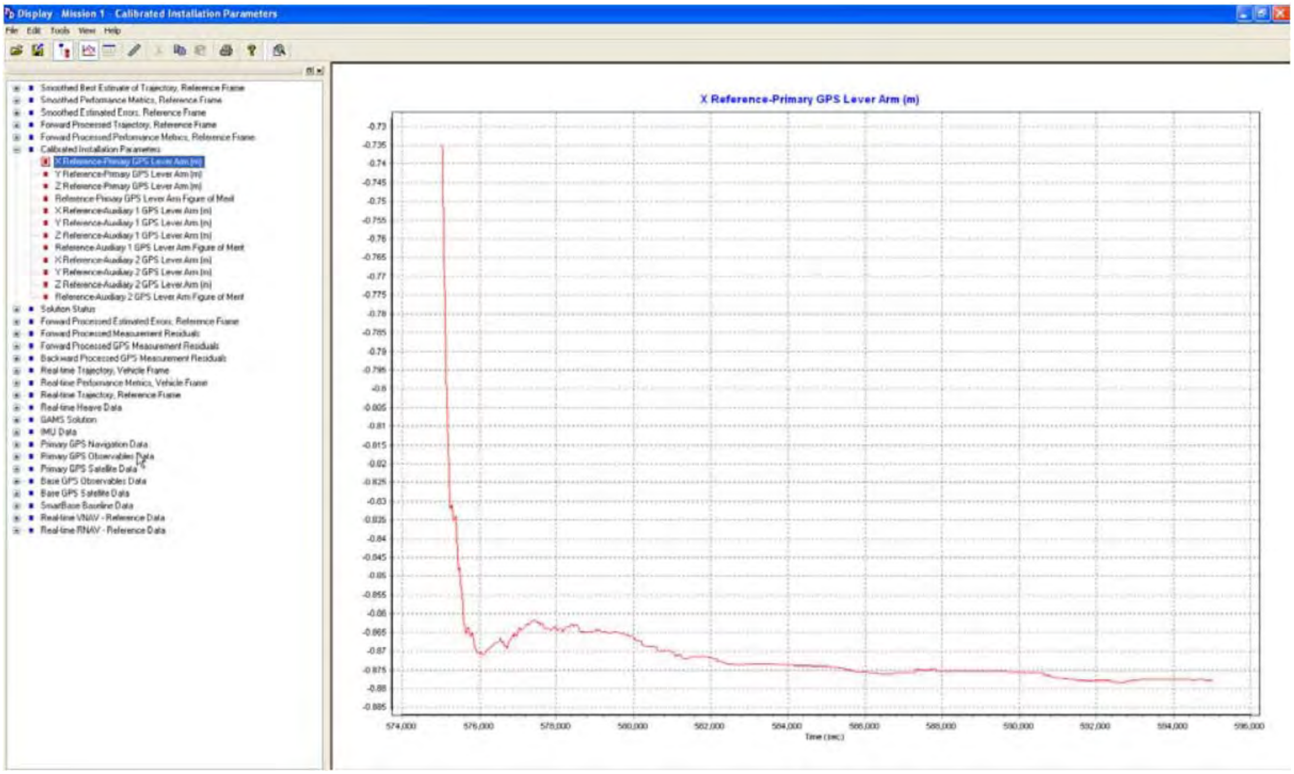
o **Altitude**. Found under “Smoothed Best Estimate of Trajectory” and “Altitude.” Oscillation is normal as it reflects vessel motion, and usually a general tidal trend can be seen. Large spikes should not be present; since this is the computed altitude the error will definitely carry through to any data the SBET is applied too. If large spikes are present, try alternate processing methods. The following is normal:



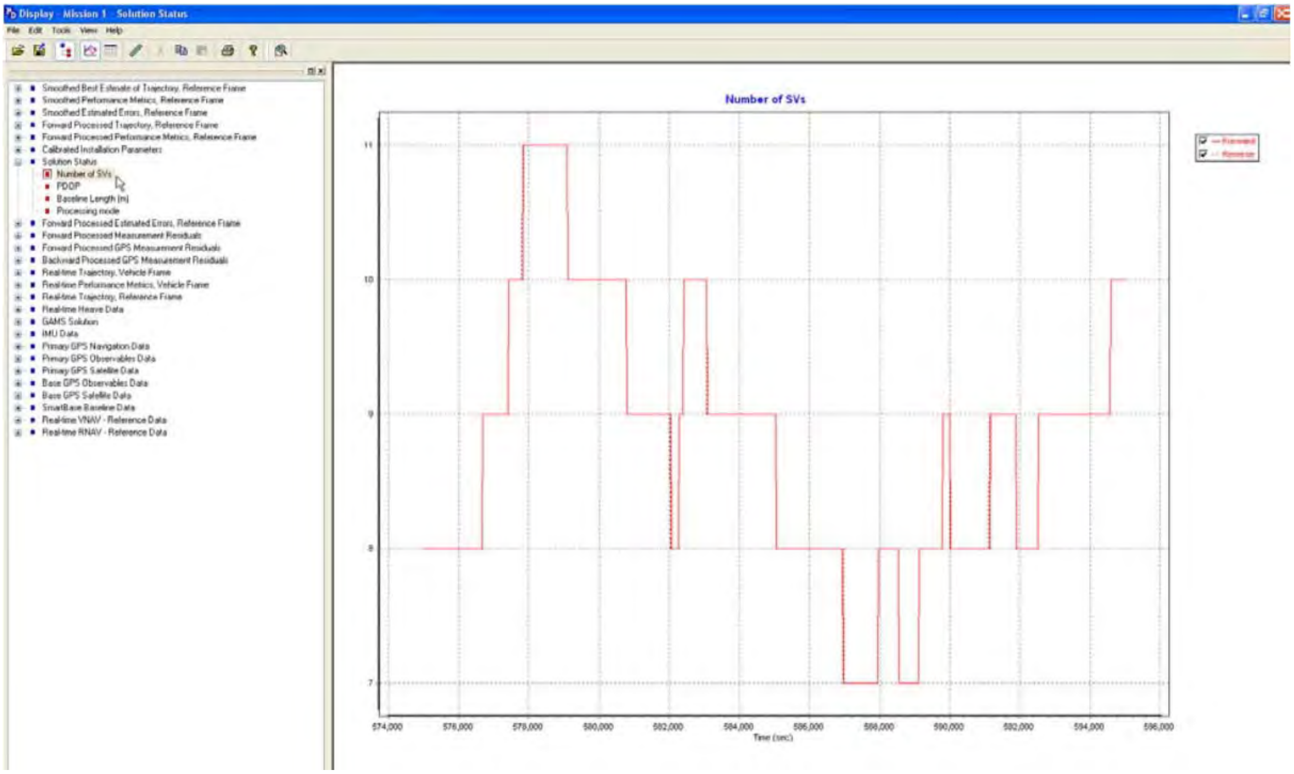
o **RMS Data.** Found under “Smoothed Performance Metrics, reference frame” and North, East, and Down Position Error RMS (m). The RMS should be better than 10 cm (not including the first and last spike when no line data is being logged). A more realistic error is less than 5cm. The example below is about .04m.



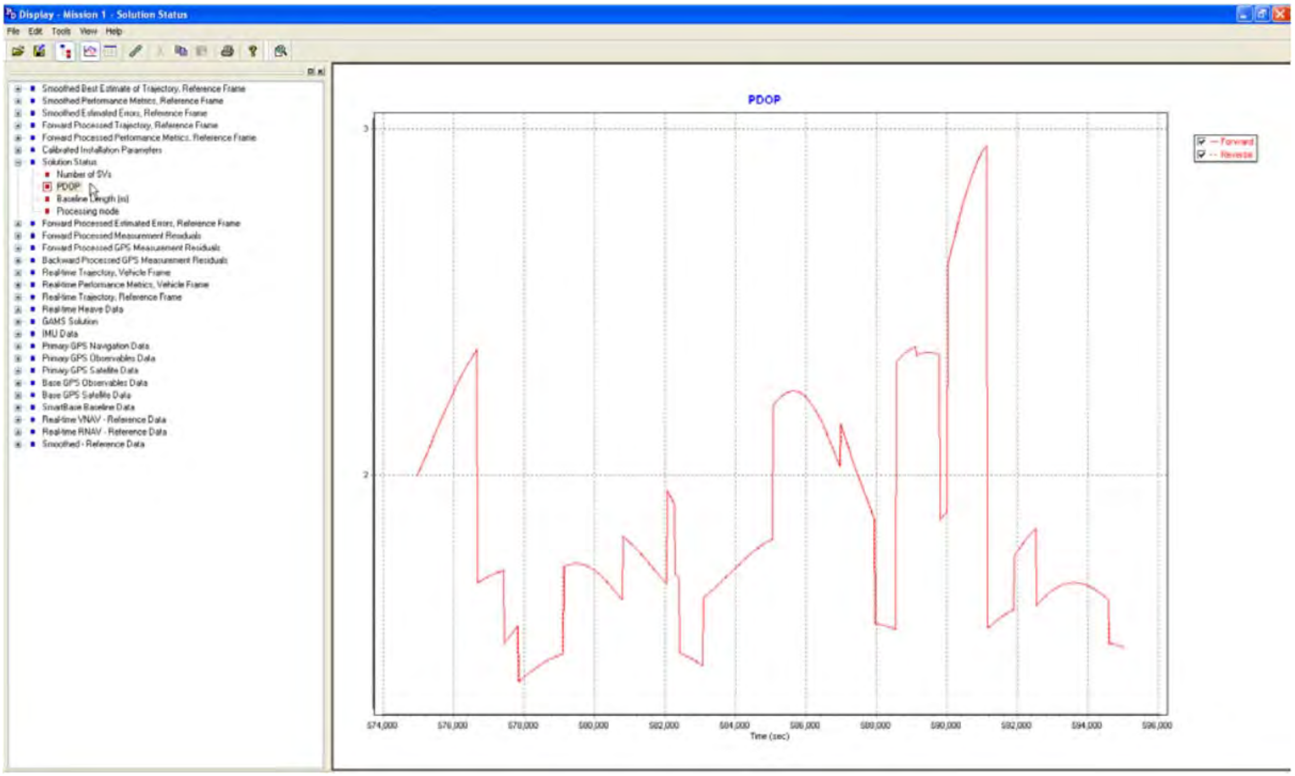
o **Calibrated Installation Parameters.** Found under “Calibrated Installation Parameters” and then X, Y, and Z Reference- Primary GPS Lever Arm. These values should settle out to an approximate value for x, y and z. Record these settled values in the SBET Check sheet and look for similar values for each vessel.



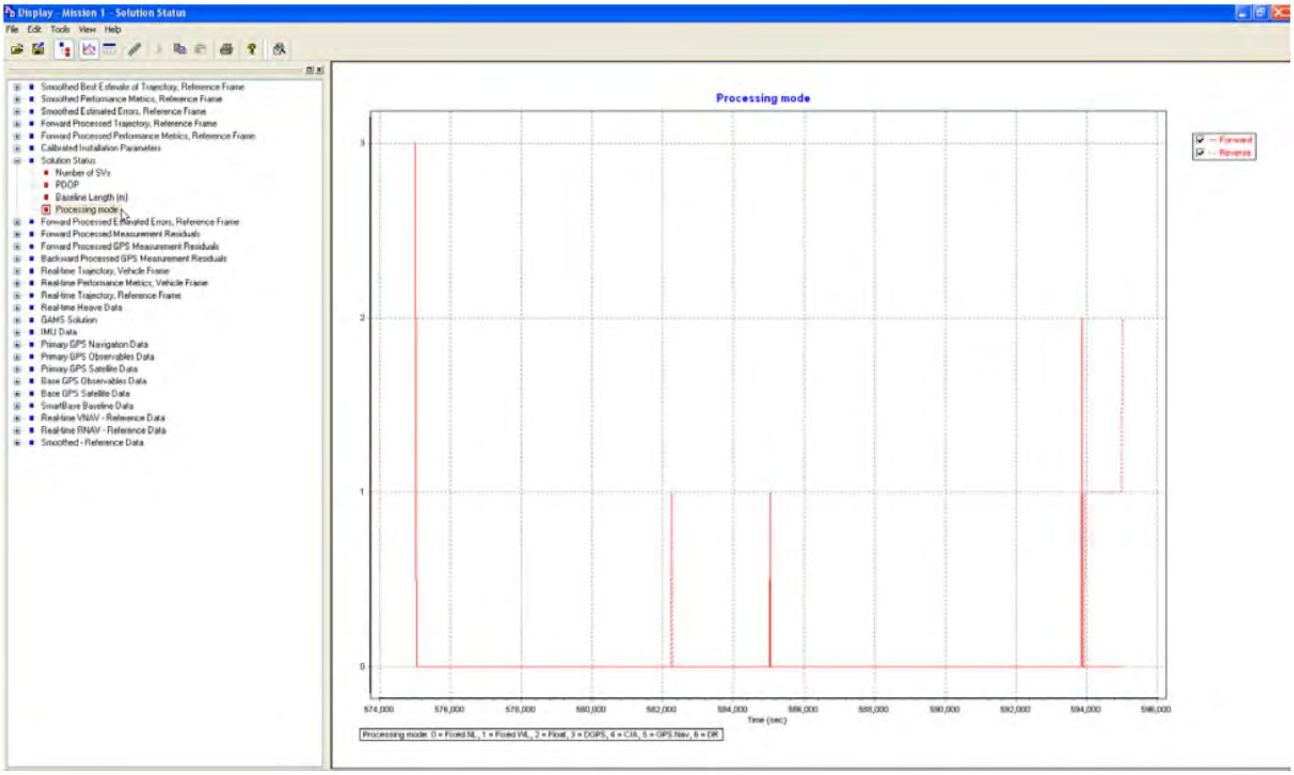
o **Number of SV's.** Found under "Solution Status" and then Number of SVs. The number of satellites should be five or more. Drops in satellite numbers can be seen in the RMS error data.



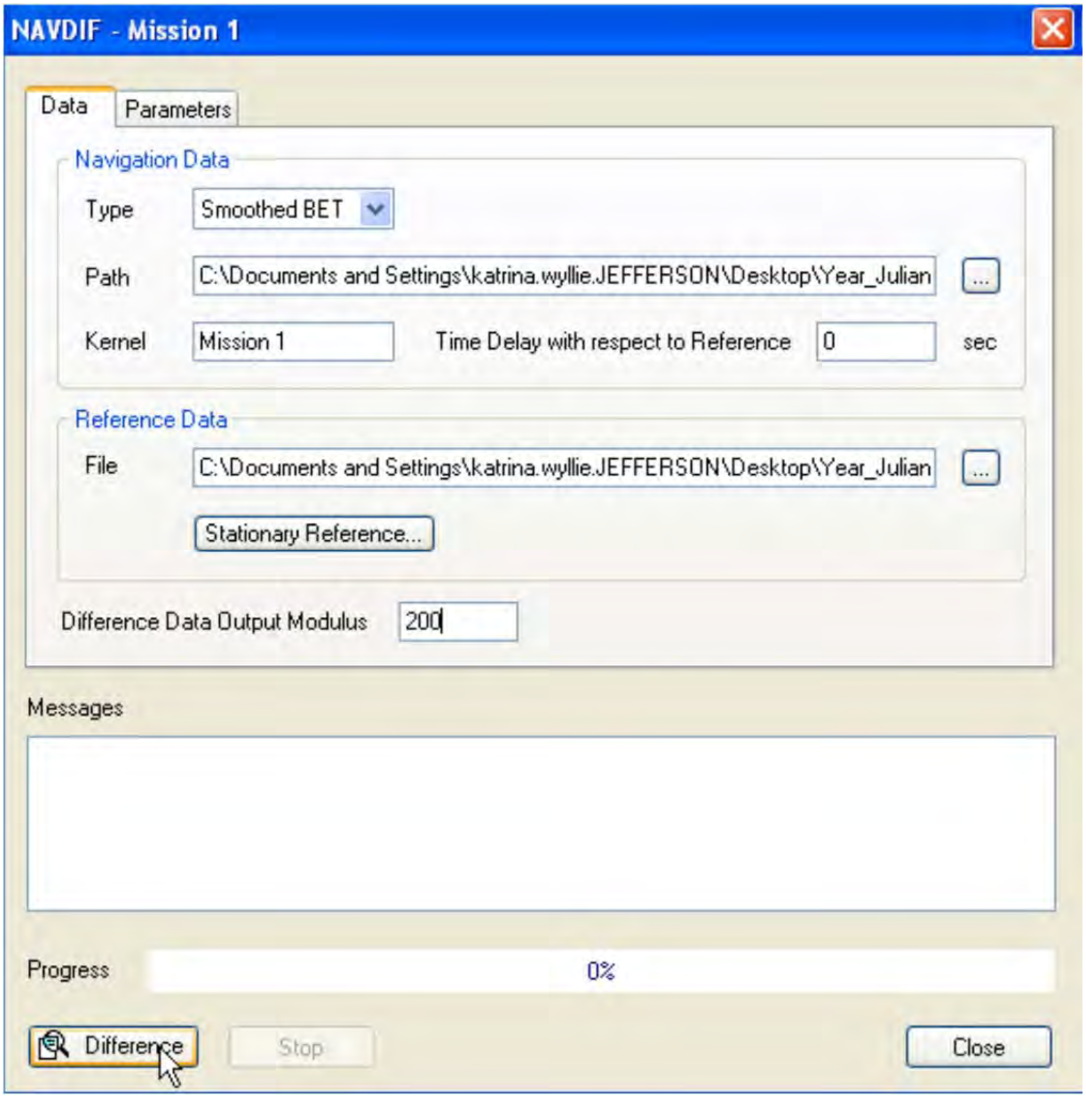
o **PDOP.** Found under “Solution Status” and then PDOP. The PDOP values are usually below 3. The FPM has guidelines to keep this number below 6. When PDOP goes above three, there is correlation in RMS error jumps.



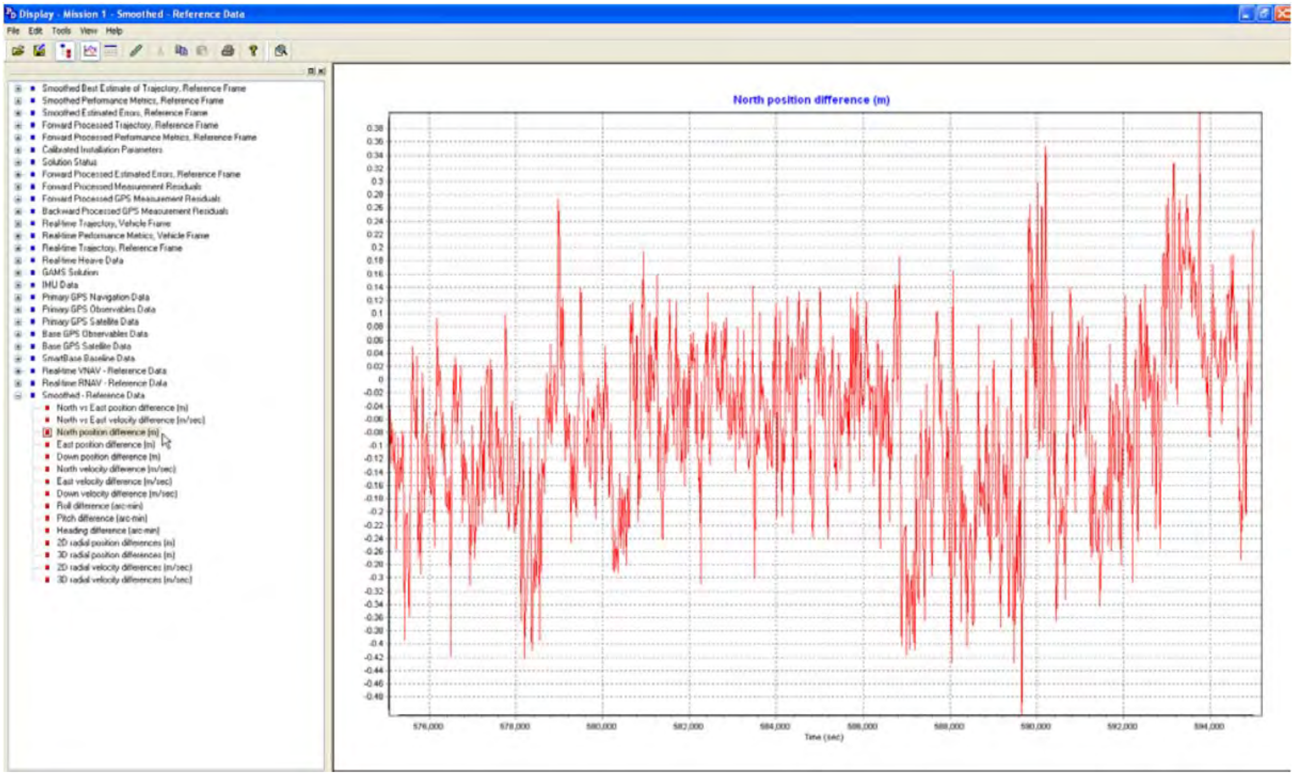
o **Processing mode.** Found under “Solution Status” and then Processing mode. There is a key below this plot that identifies the numerical value of the processing mode. The best solution would be a 0, or Fixed NL. Record the values in the SBET Check sheet.



o **Smoothed- Reference Data**. First, click on Tools, NAVDIF. Under the Reference Data file, browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Extract folder and select vnav_Mission 1.out. Change the Difference Data Output Modulus to 200. Click Difference.



You are differencing the real-time navigation to the SBET solution. When the difference is done, close the NAVDIF box. A new plot will pop up, called Smoothed- Reference Data. Look at the North, East and Down position difference (m) plots. The min/max values for North and East differences should be within +/- 0.50m. The min/max values for the Down difference should be +/- 1m



Step Eight: Export, Rename SBET and Associated Error File

• Browse to H:\Surveys\HXXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the sbet_Mission 1.out file and rename it to *"Year_JulianDay_Vessel_SBET.out."*

• Browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the smrmsg_Mission 1.out and rename it to *Year_JulianDay_Vessel_RMS.out*

USING POSPAC MMS 5.4 TO PROCESS GPS (SMARTBASE)
SMARTBASE BATCH PROCESSING

Open POSPac MMS 5.4 and select Run -> Batch Manager, see figure 1 below.

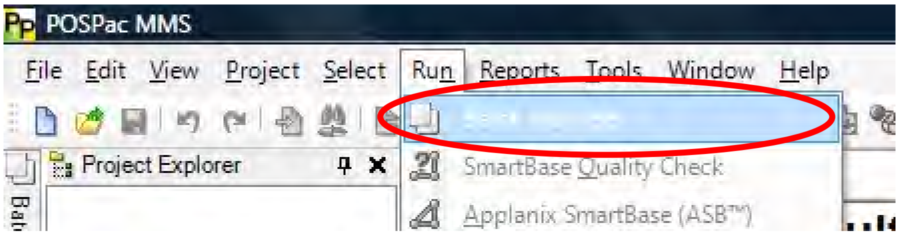


Figure 9

This will bring up the *Batch Manager*. Click the New Batch icon in the upper left corner of the pane, see figure 2 below.

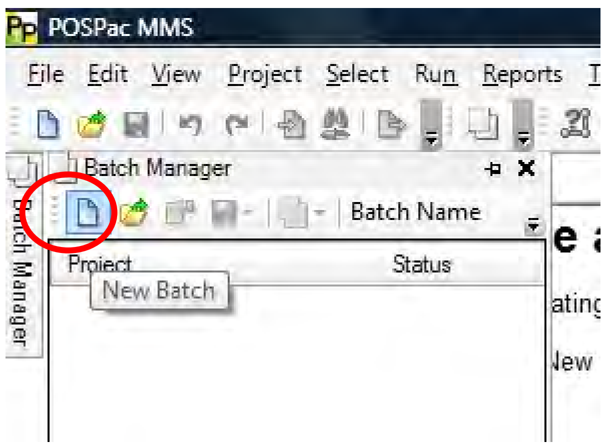


Figure 10

This will bring up the save file dialog for the batch configuration file. Save the batch configuration file to the POSPAC folder in the appropriate project,

W:/Control/HORCON/Projects/20YY/OPR-XXXX-FA-YY/POSPAC
(i.e. W:/Control/HORCON/Projects/2009/OPR-O119-FA-09/POSPAC/)

Use the naming convention sheetnumber_daynumber as in “HXXXXX_DDD.posbat” (i.e. H12072_172.posbat) for the batch configuration file.

After saving the batch configuration file the batch editor dialog will come up, see figure 3. Enter the POSPac project name, of which there is one for each POSPac (true heave) file. Use the name "YYYY_DDD_VVVV" where YYYY is the year, DDD is the day number, and VVVV is the vessel. On the *POS Data Location* tab use the open file button to the right of the *First File* field to navigate to and select the appropriate POS data file for the vessel and day (the *Last File* field will auto fill with the same file name and only needs to be explicitly set if multiple POS data files were logged in immediate succession). POSPac files from 1010, 1018, and S220 are stored under the H:\Raw drive under the boat day folder as .000 files. ***DON'T USE ANY .000.FIXED FILES-USE THE RAW POSPAC FILE OTHERWISE YOU WILL HAVE PROBLEMS!***

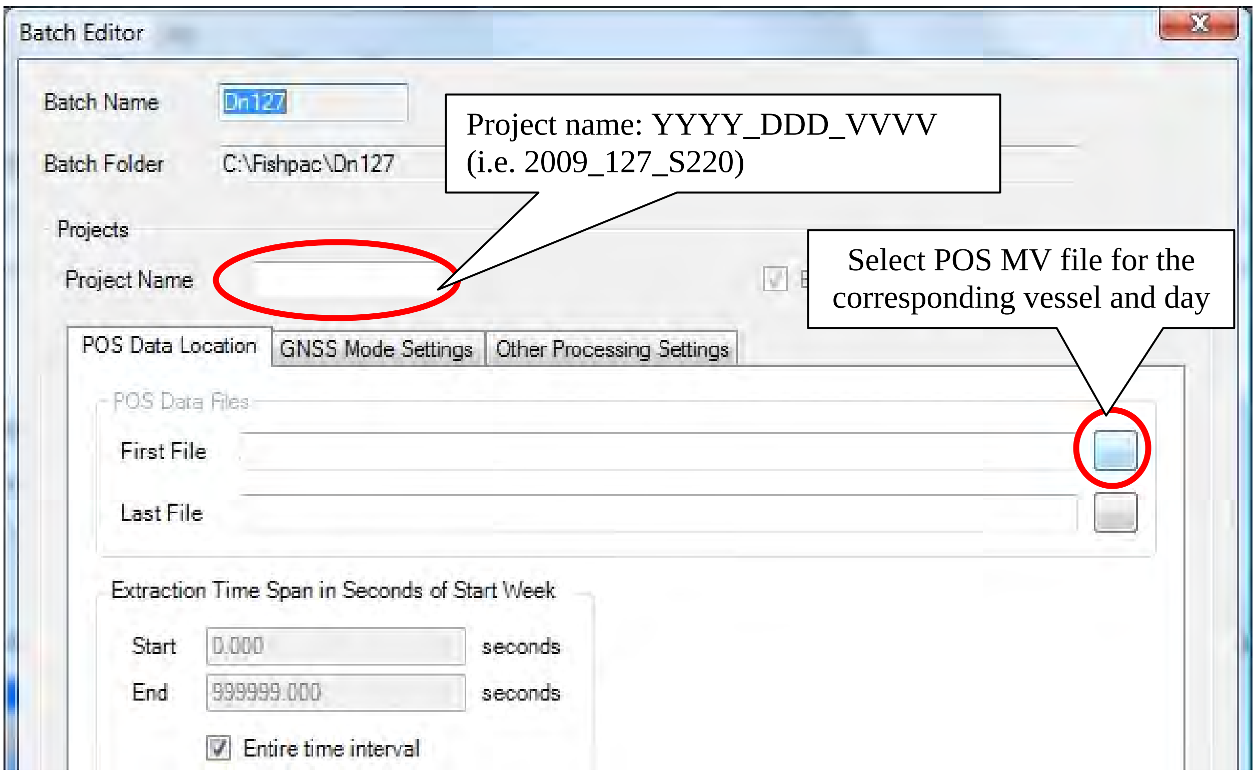


Figure 11

Under the *GNSS Mode Settings* tab leave the GNSS Mode as SmartBase; see figure 4 below.

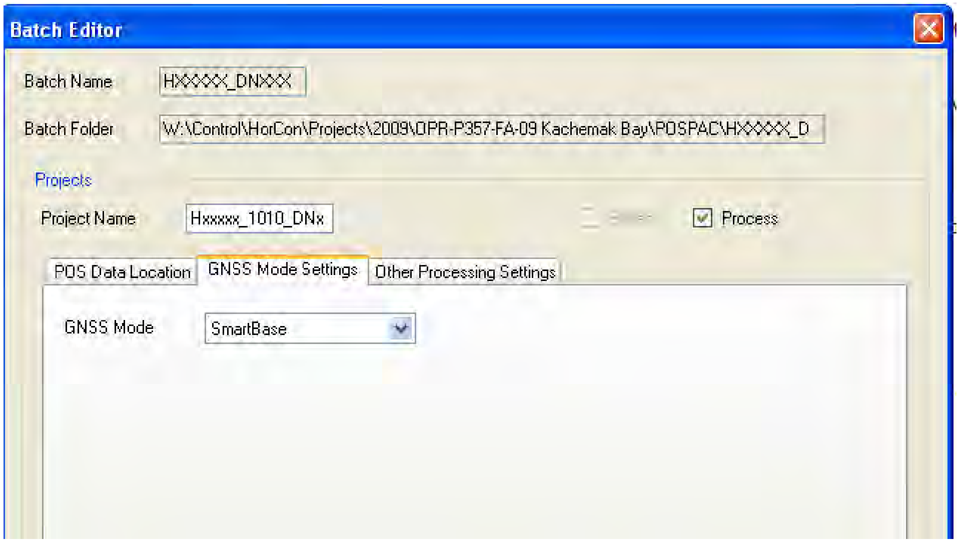


Figure 12

Towards the bottom of the *Batch Editor* dialog click the *Add* button, see figure 5 below, this will add the project to the processing queue.

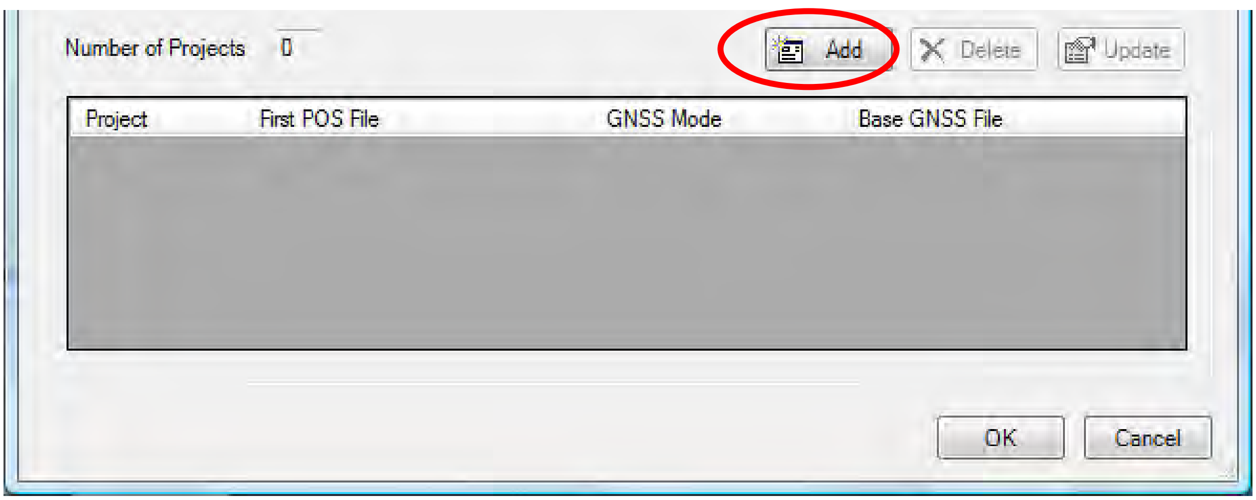


Figure 5

After the project has been added to the queue all the fields in the *Batch Editor* will stay unchanged. Return to the *POS Data Location* tab seen in figure 3. For each POS data file from the same day for other vessels update the *Project Name* and select the appropriate POS data file in the *First File* field and click *Add* towards the bottom of the window.
After all projects have been added to the queue click *OK*.

Back in the main window the *Batch Manager* pane will update with a list of the projects that you added to the queue and the various tasks that will be performed for each project, see figure 8. **Be sure you have the POSPac key in your computer** and then select the Run Batch button, see below.

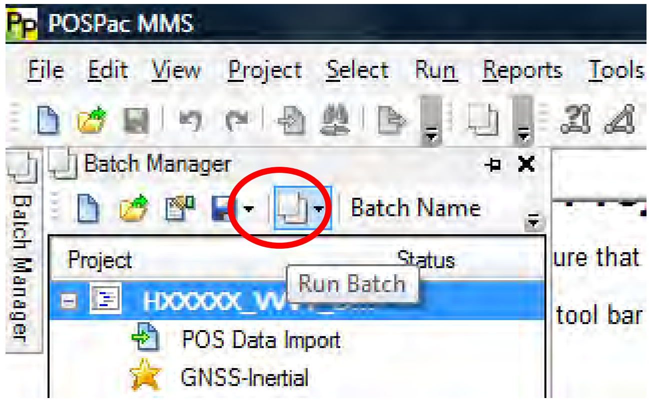


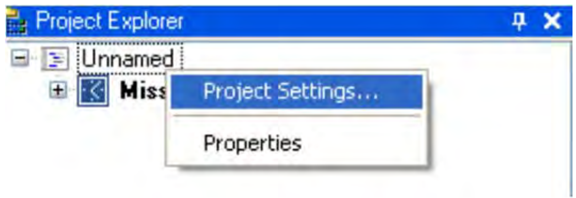
Figure 13

This will start the processing of all the projects in the queue, come back later to check that they all successful completed.

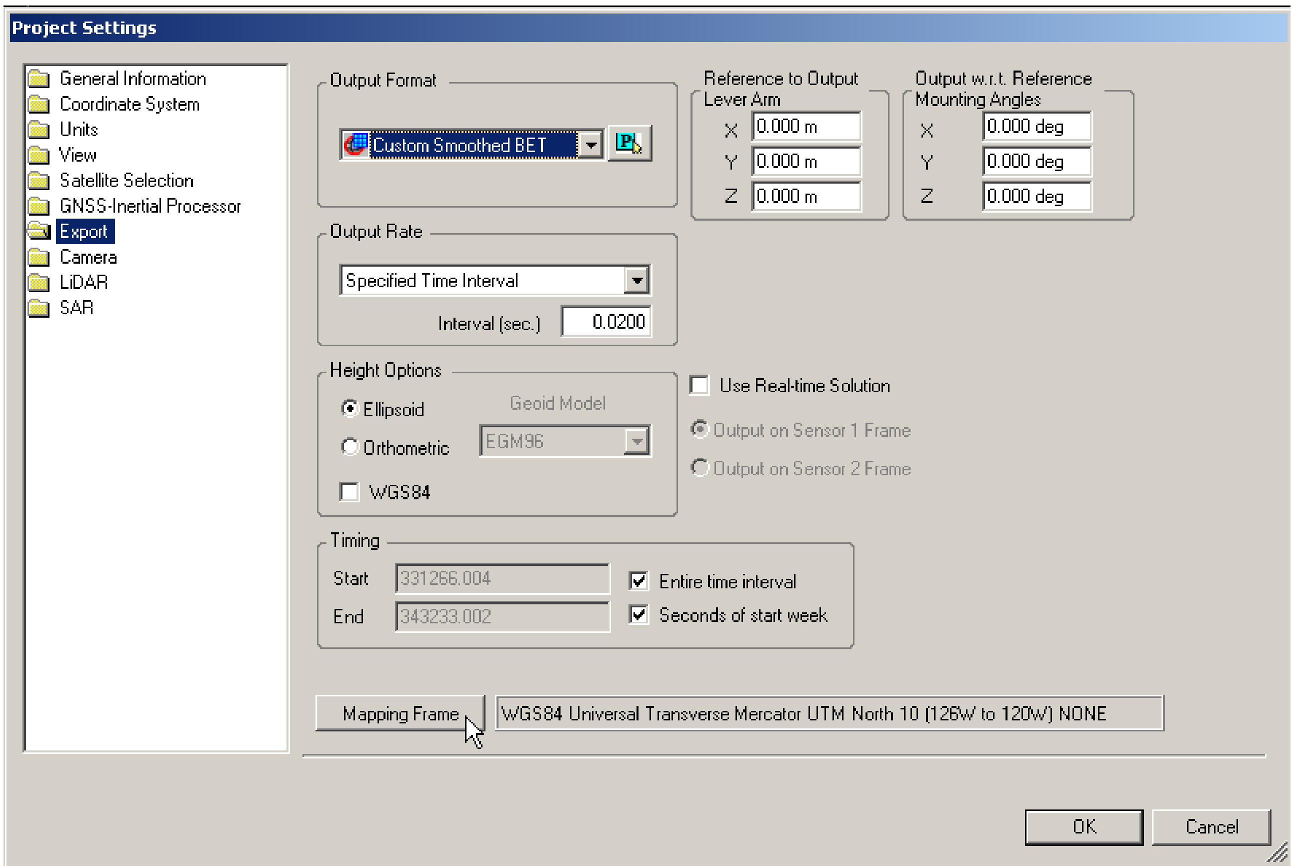
USING POSPAC MMS 5.4 TO PROCESS GPS (PPP)

Step One: Create POSPac MMS 5.4 Template

- File, New Project, double click on <Blank Template>
- Under Project Explorer, right mouse click on Unnamed and select Project settings

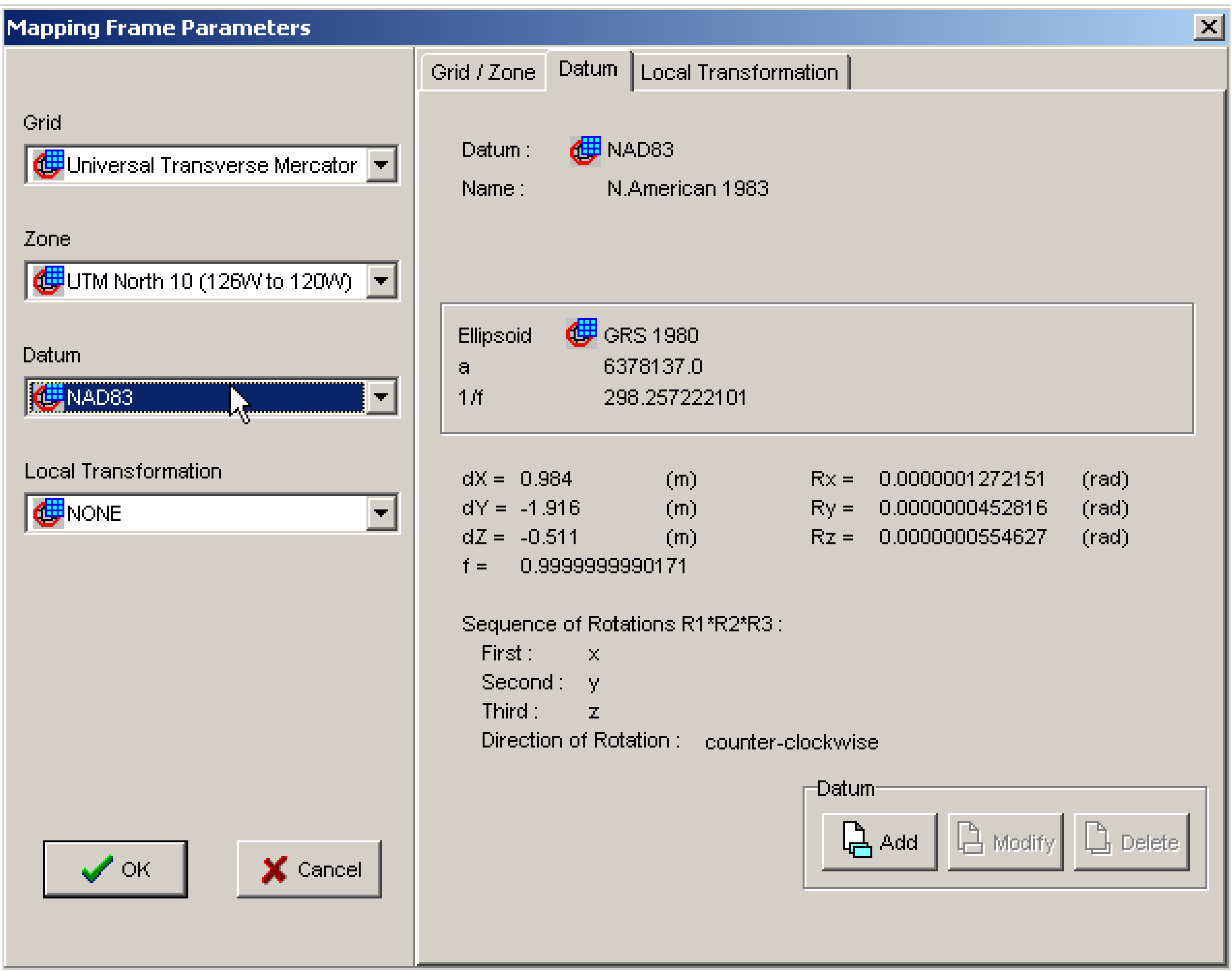


- Navigate to the export tab and change the output format to “Custon Smoothed BET” with an output rate “specified time interval” of 0.02 seconds. Unclick “Use Real-Time solution” box.

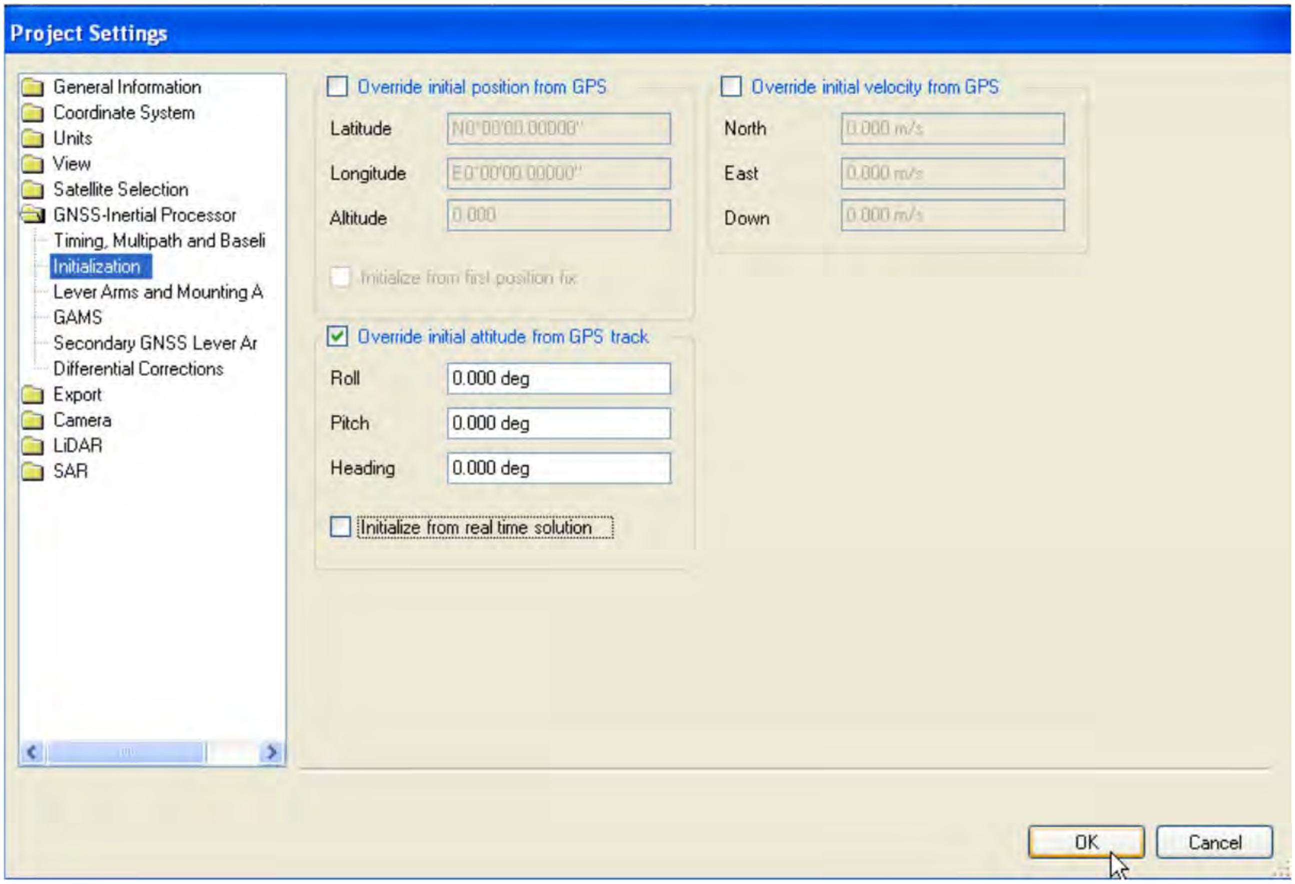


• Select the “Mapping Frame” option at the bottom to bring the up the below image. It is extremely important here to specify output datum to NAD83. Unlike “SingleBase” or “SmartBase” processing where we’ve manually forced POSPac to process in NAD83 by modifying the reference station position, PPP by nature, doesn’t have reference stations to modify. Since all PPP downloaded data (Step 4 below) will be ITRF centric, we have to perform a datum transformation within POSPac upon export to ensure our 3-D navigation solution is relative to NAD83.

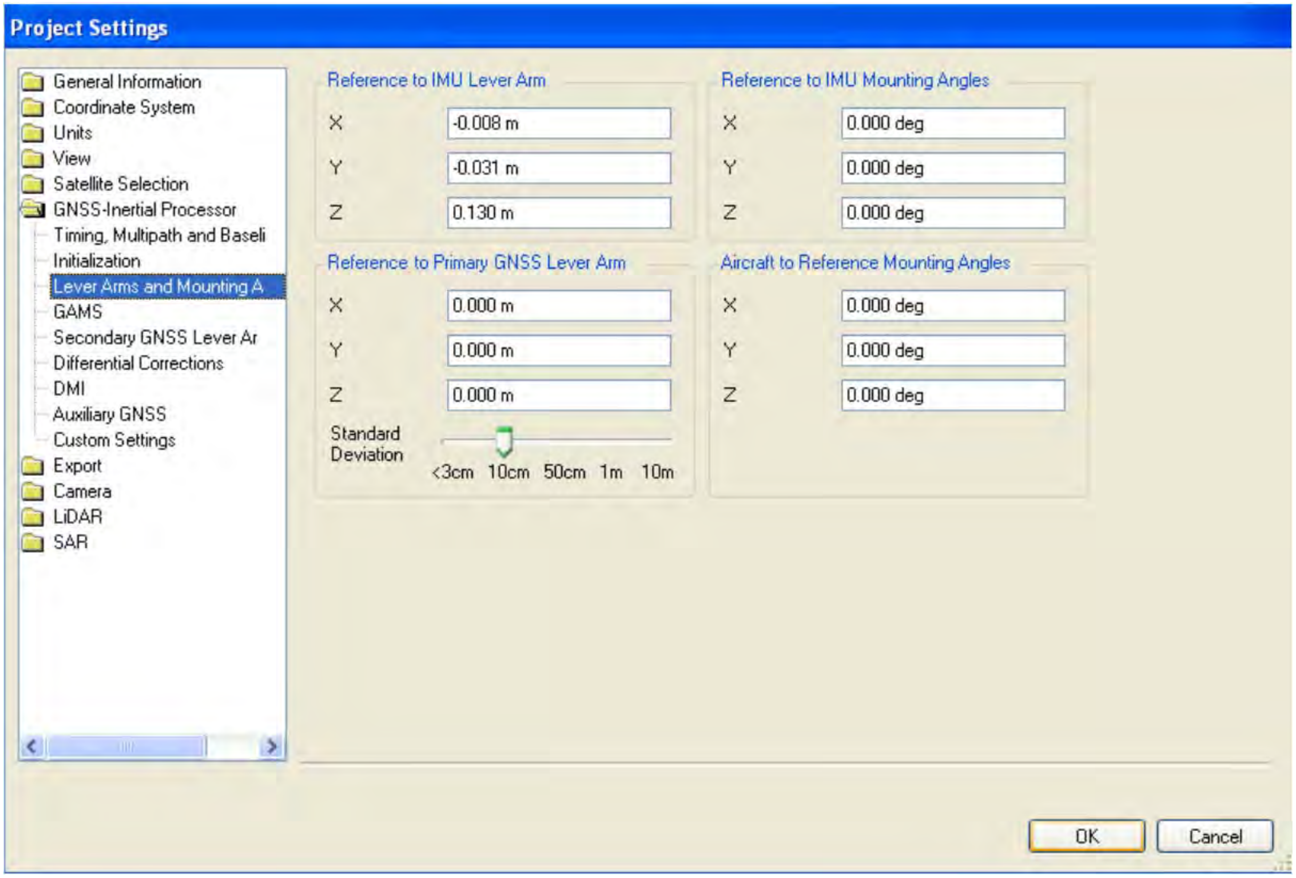
Note: This Custom Smoothed Bet datum transformation procedure is also required in “SingleBase” and “Smartbase” if data is left relative to ITRF during data processing. However this procedure is not currently recommended.



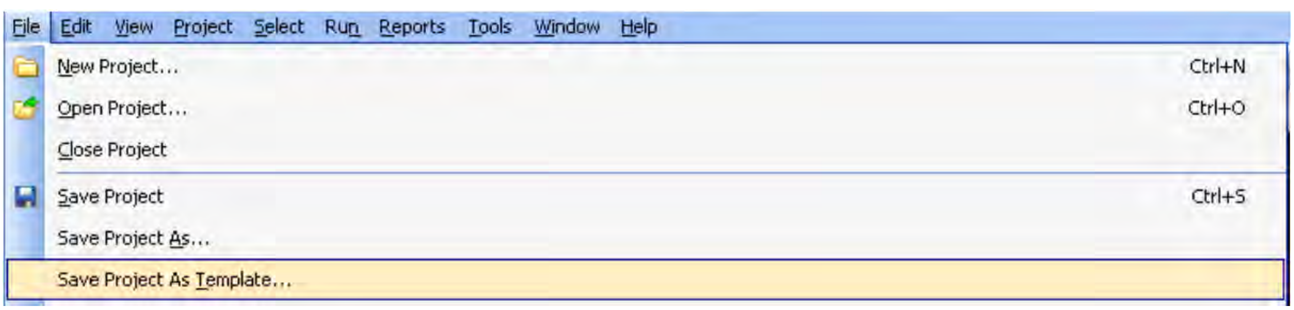
• Navigate to the Initialization tab and ensure the Initialize from real time solution box is *unchecked*



• Navigate to the Lever Arms and Mounting Angles tab and enter Reference to IMU Lever Arm values as shown (-0.008, -0.031,and 0.130):



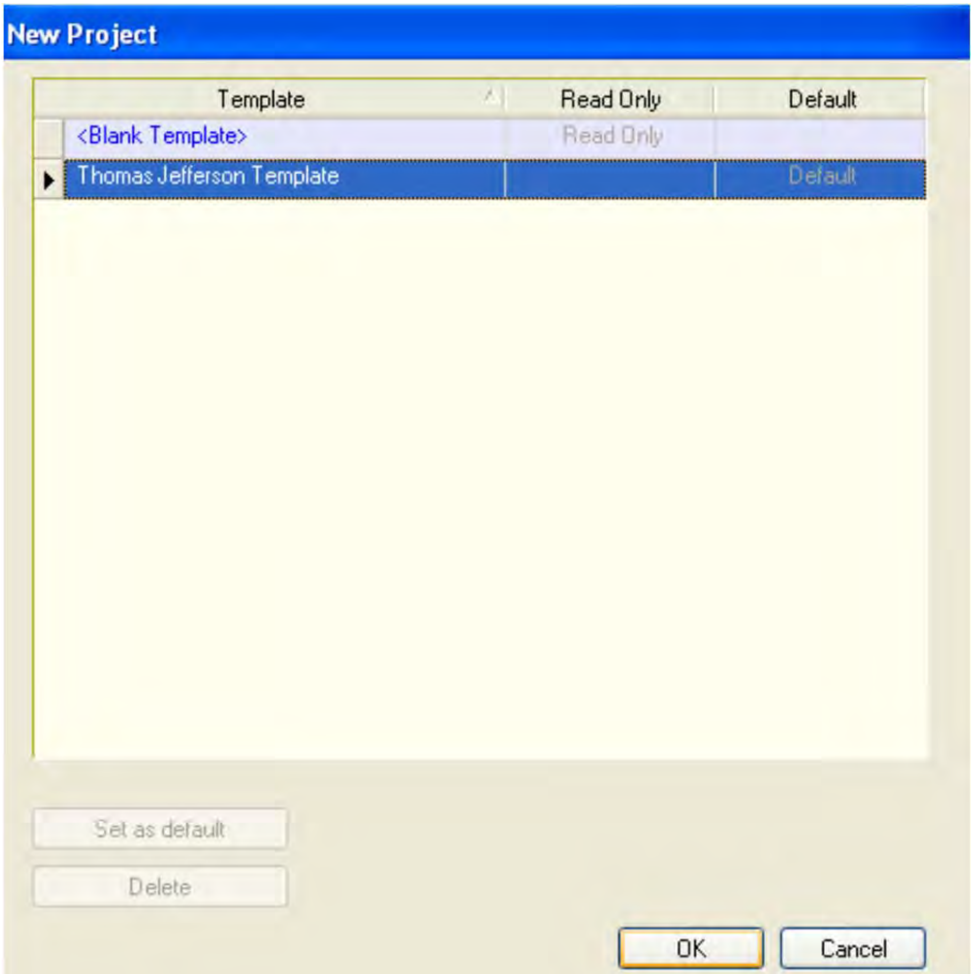
• File, Save Project As Template



• Name the template *NOAA_SHIP_Template* and click the set as default button, then ok

Step Two: Create a POSPac 5.4 Project:

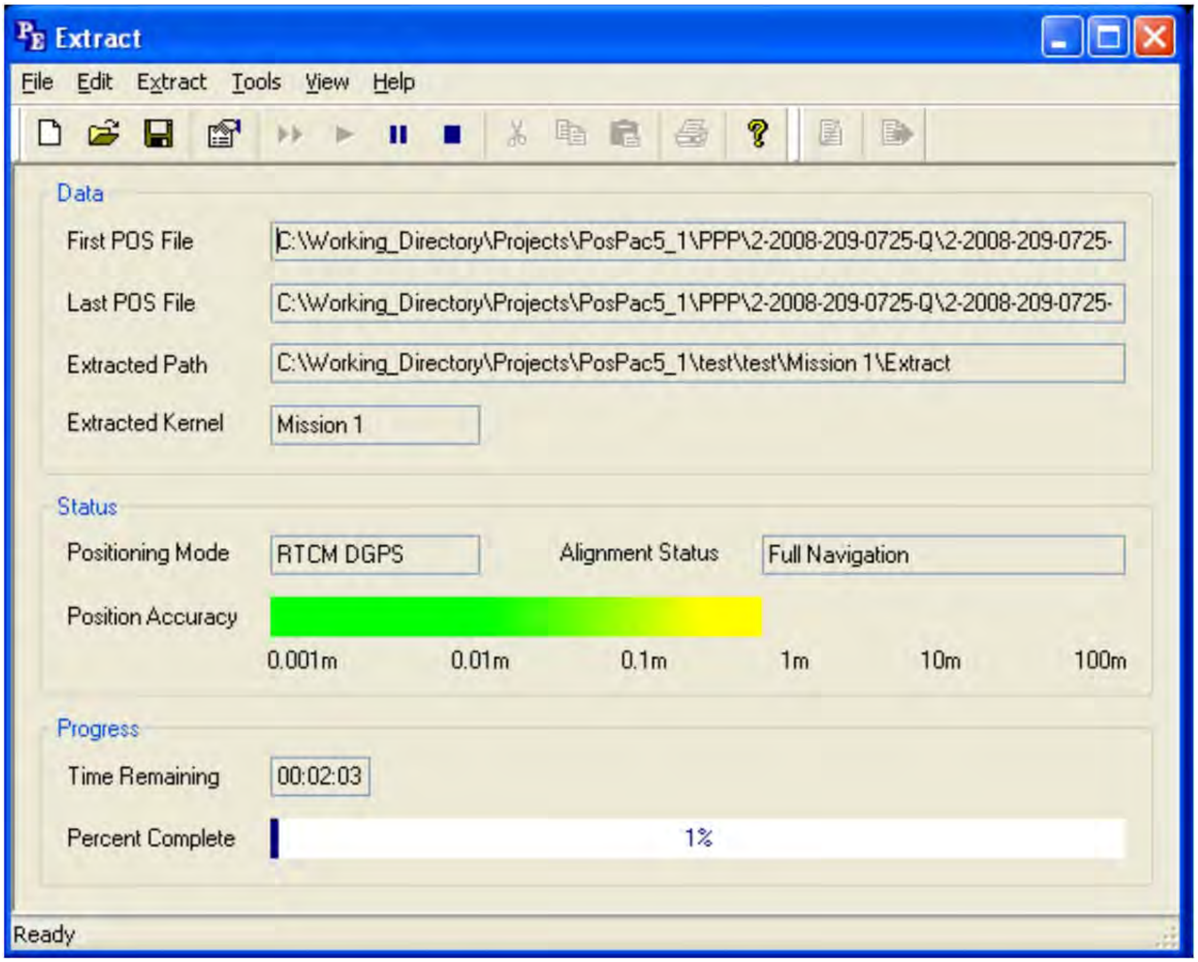
• File, New project. Highlight the template created in Step One and click OK



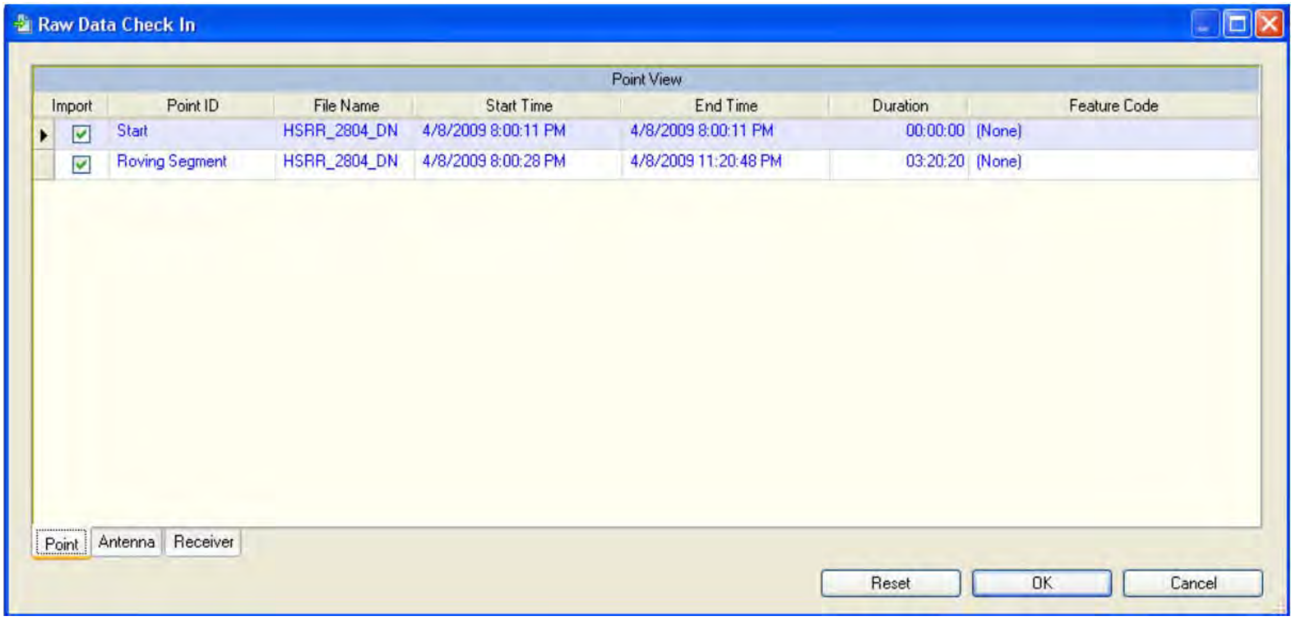
• File, Save Project. Save as *Year_JulianDay_Vessel*

Step Three: Import the Raw POS

• Open a windows explorer window and locate the UNFIXED true heave file for the specific project, vessel and day. **Drag and Drop your .000 file into the Plan View window**



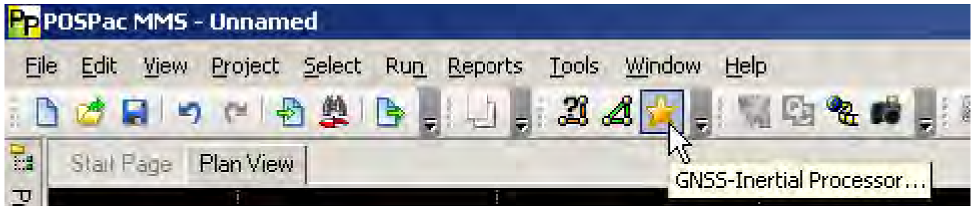
• Say OK at the following window. Antenna and Receiver should remain unknown for the POS data.



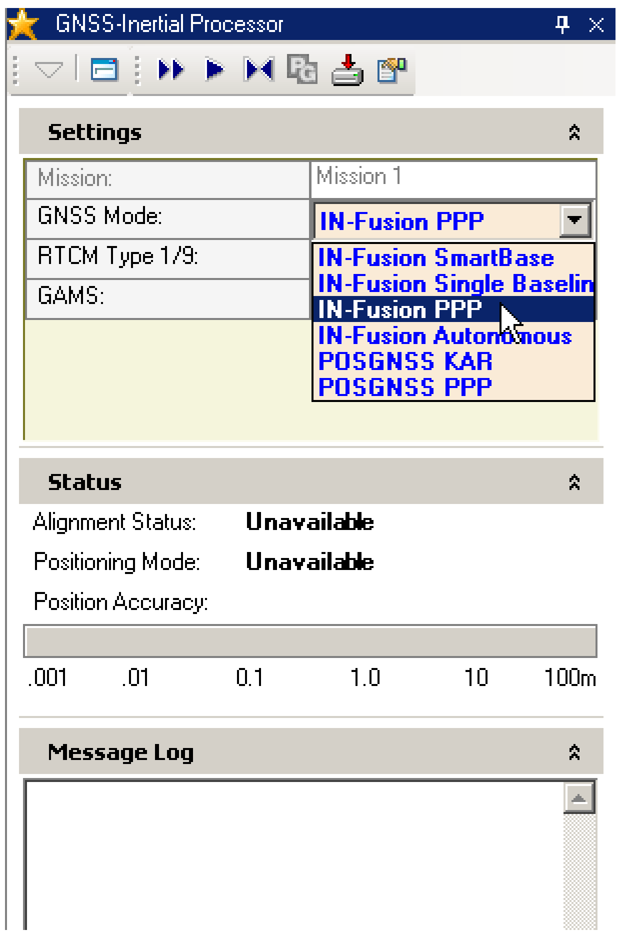
• The project definition can remain unchanged. Simply select "OK"

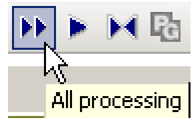
Step Four: GNSS Inertial Processor using PPP

• From the toolbar select Process or go to Run on the top Menu and select GNSS Intertial Processor.



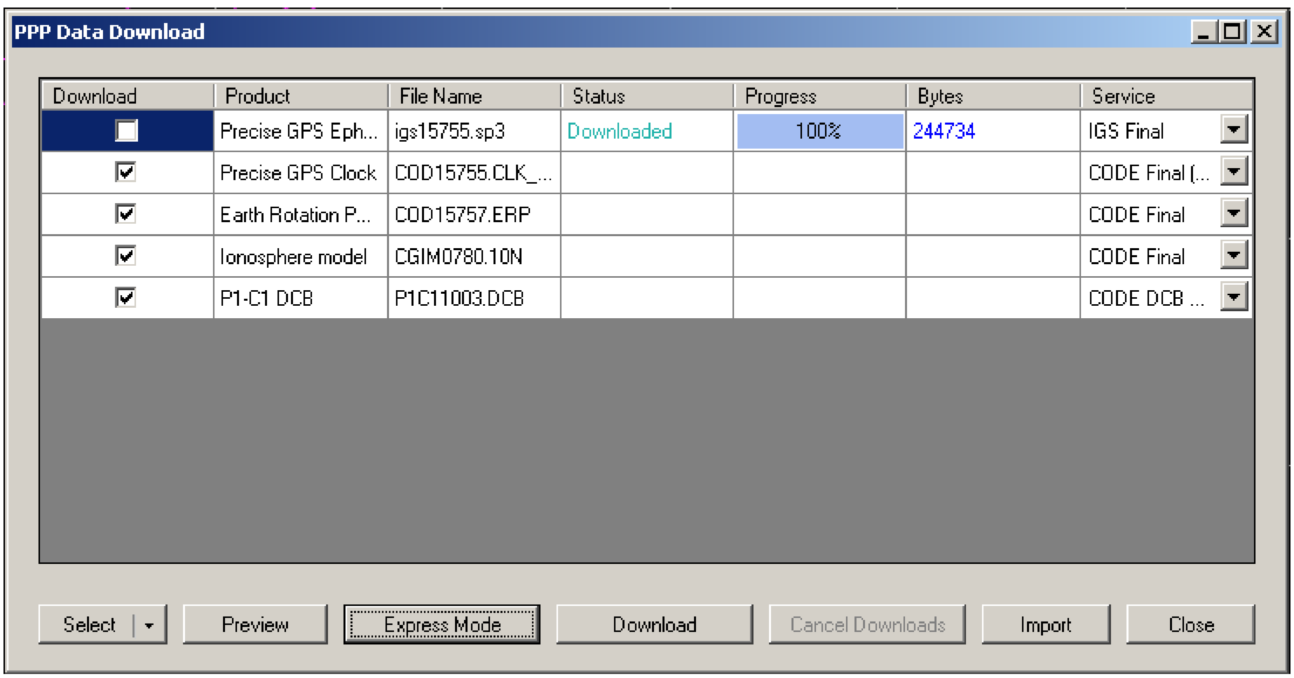
• From the pull down menu across from the GNSS Mode, Select IN-Fusion PPP



• Select Run, or click on the “All Processing icon 

to run the GNSS-Inertial process.

• When prompted, Run the PPP download.



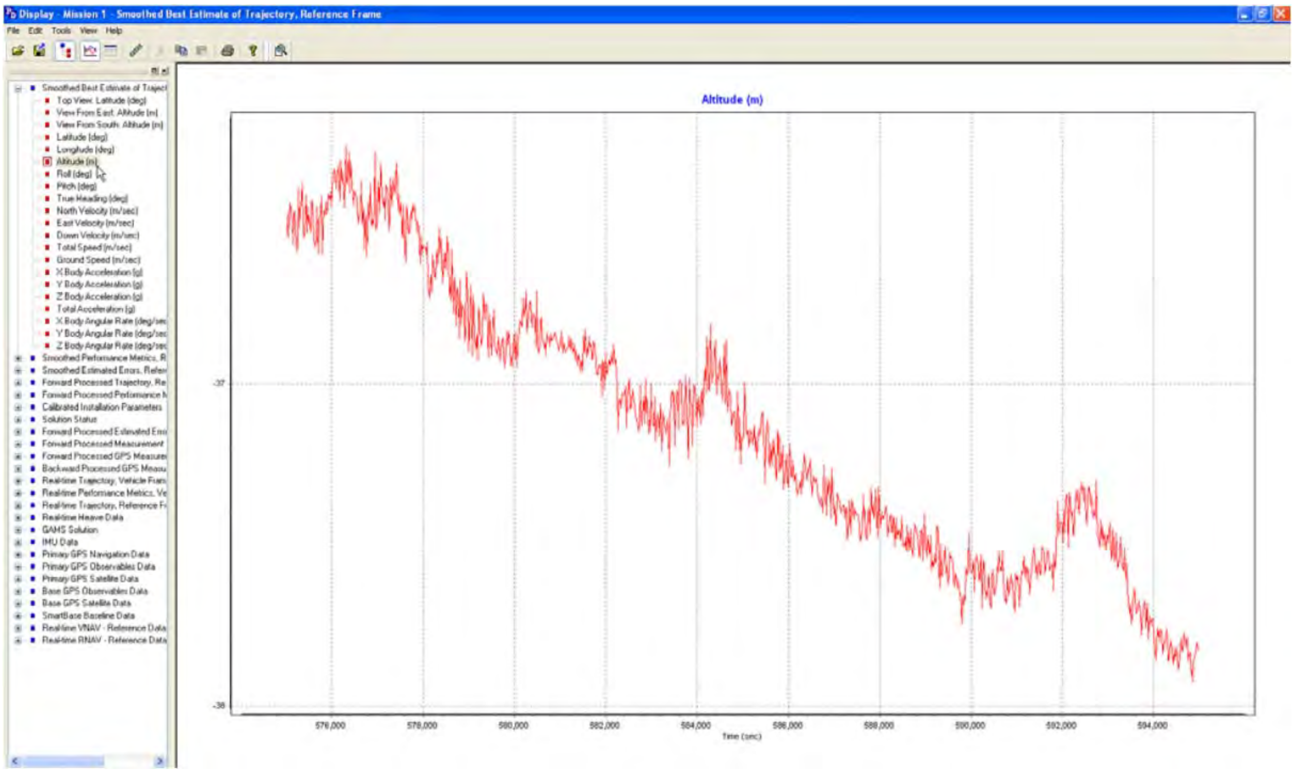
• Close when completed. The track lines should now appear green representing the data has been corrected with a fixed integer solution.

Step Five: Quality Control Checks for the SBET

• Examine the message logs for the solution. Look for serious errors, cycle slips and data gaps.

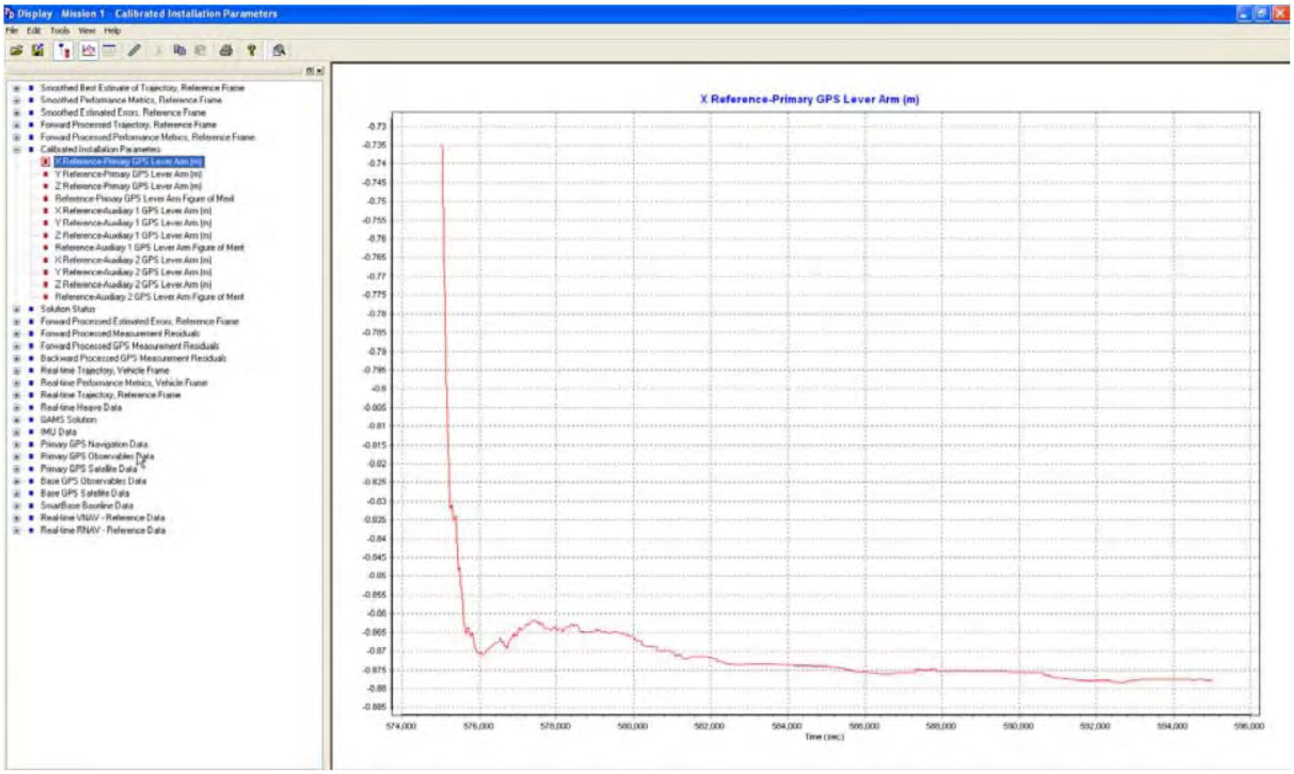
• Examine the plots for the solution. There are multiple ways to examine the data. When examining the data, ensure the HXXXXX_SBET_Checksheet.xlsx is filled out.

o **Altitude**. Found under “Smoothed Best Estimate of Trajectory” and “Altitude.” Oscillation is normal as it reflects vessel motion, and usually a general tidal trend can be seen. Large spikes should not be present; since this is the computed altitude the error will definitely carry through to any data the SBET is applied too. If large spikes are present, try alternate processing methods. The following is normal:

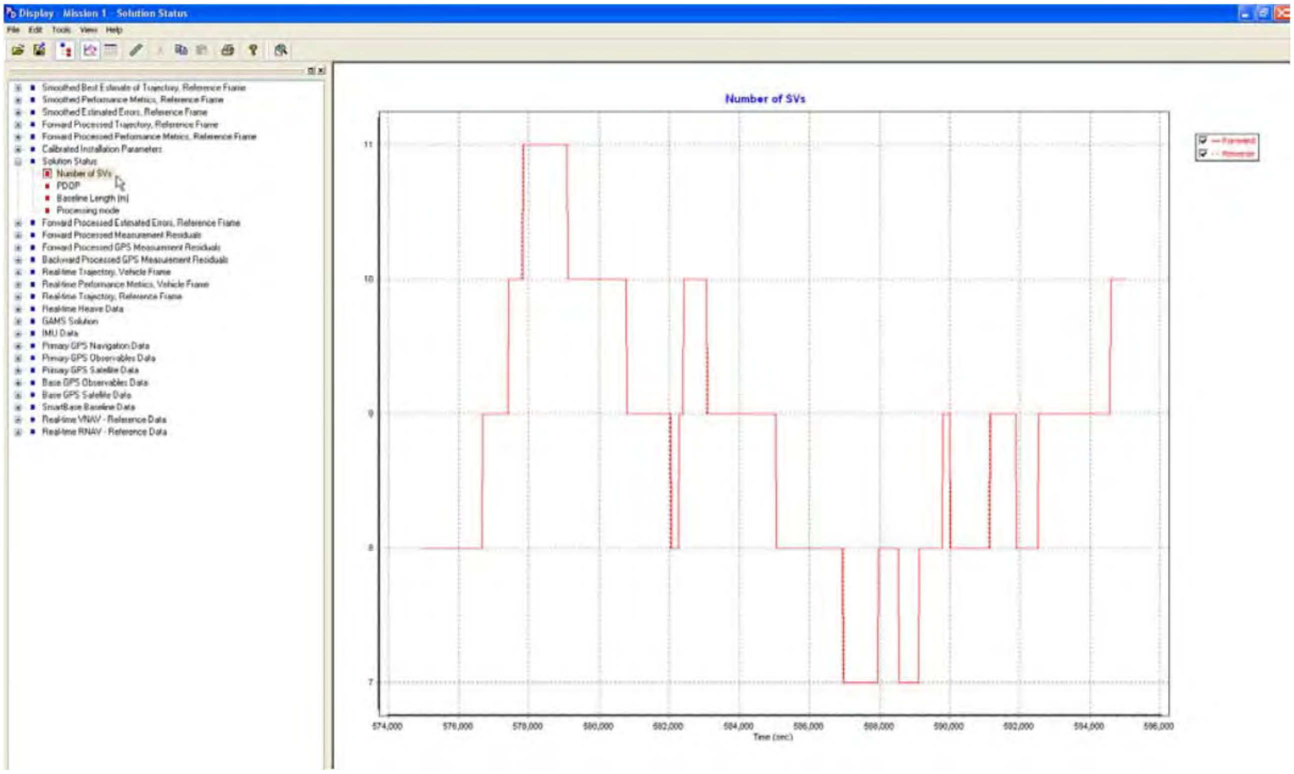


o **RMS Data.** Found under “Smoothed Performance Metrics, reference frame” and North, East, and Down Position Error RMS (m). The RMS should be better than 10 cm (not including the first and last spike when no line data is being logged). A more realistic error is less than 5cm. The example below is about .04m.

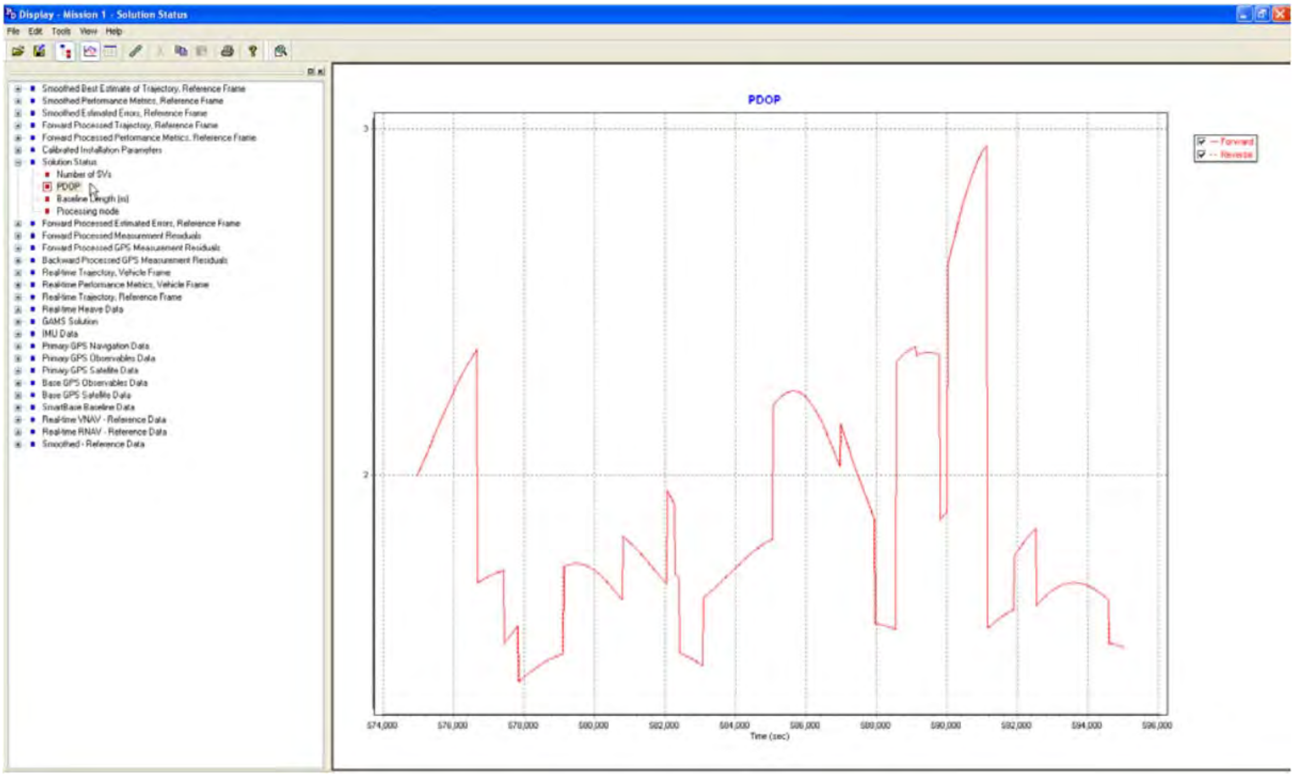
o **Calibrated Installation Parameters.** Found under "Calibrated Installation Parameters" and then X, Y, and Z Reference- Primary GPS Lever Arm. These values should settle out to an approximate value for x, y and z. Record these settled values in the SBET Check sheet and look for similar values for each vessel.



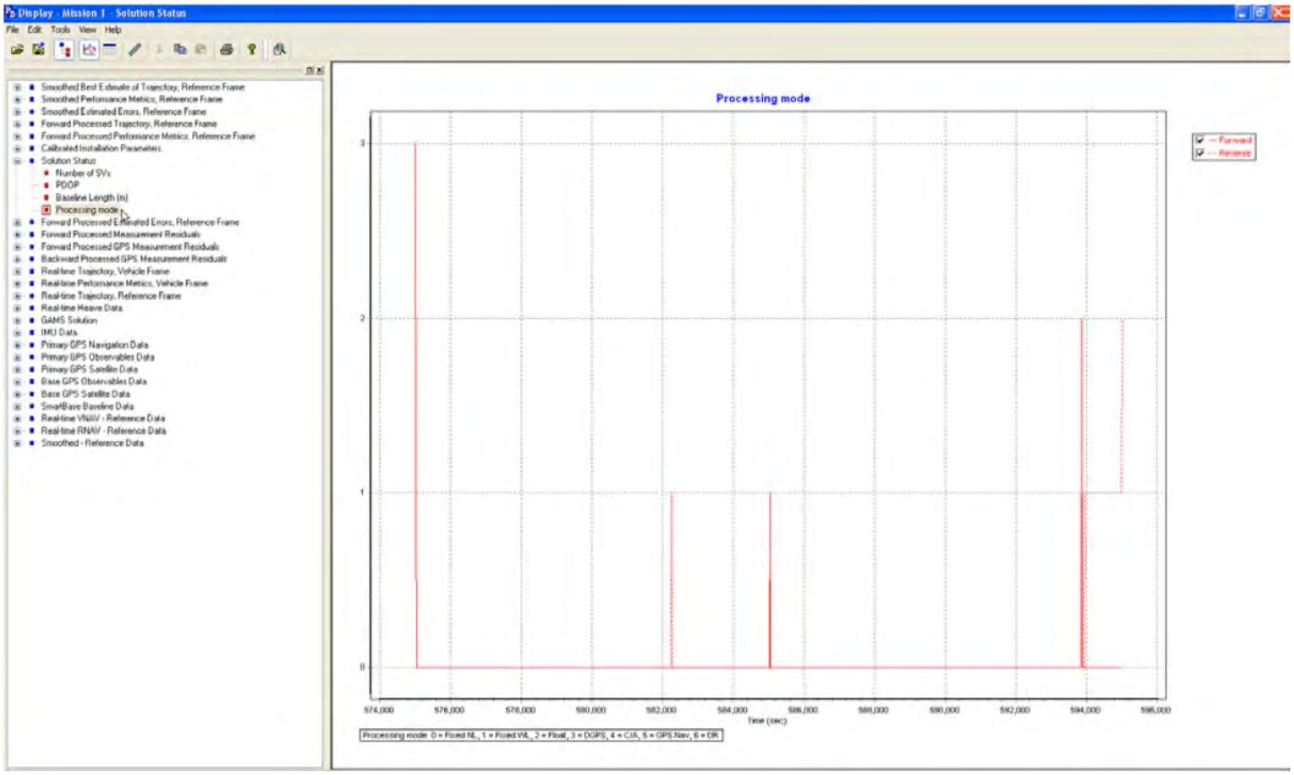
o **Number of SV's.** Found under "Solution Status" and then Number of SVs. The number of satellites should be five or more. Drops in satellite numbers can be seen in the RMS error data.



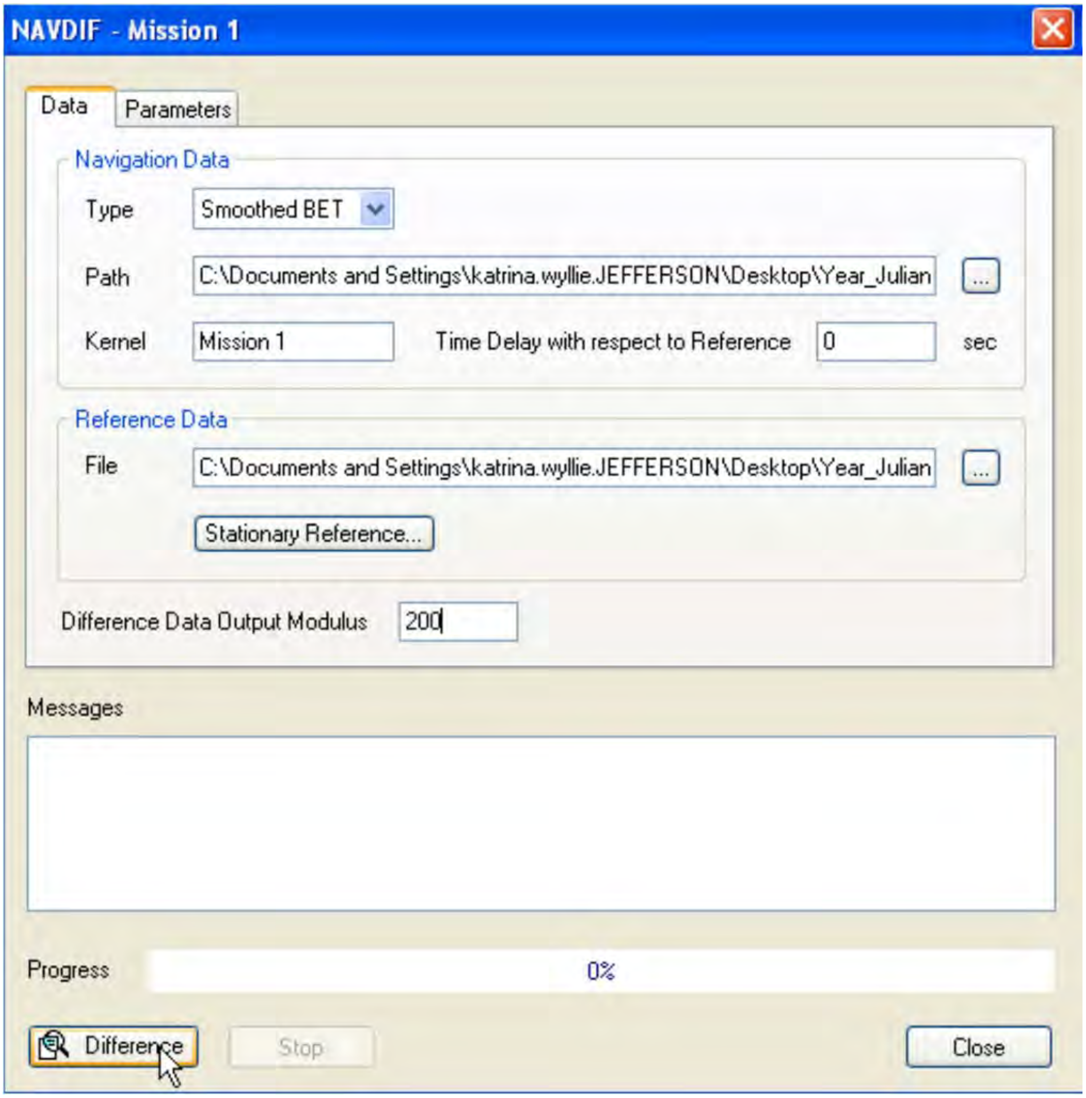
o **PDOP.** Found under "Solution Status" and then PDOP. The PDOP values are usually below 3. The FPM has guidelines to keep this number below 6. When PDOP goes above three, there is correlation in RMS error jumps.



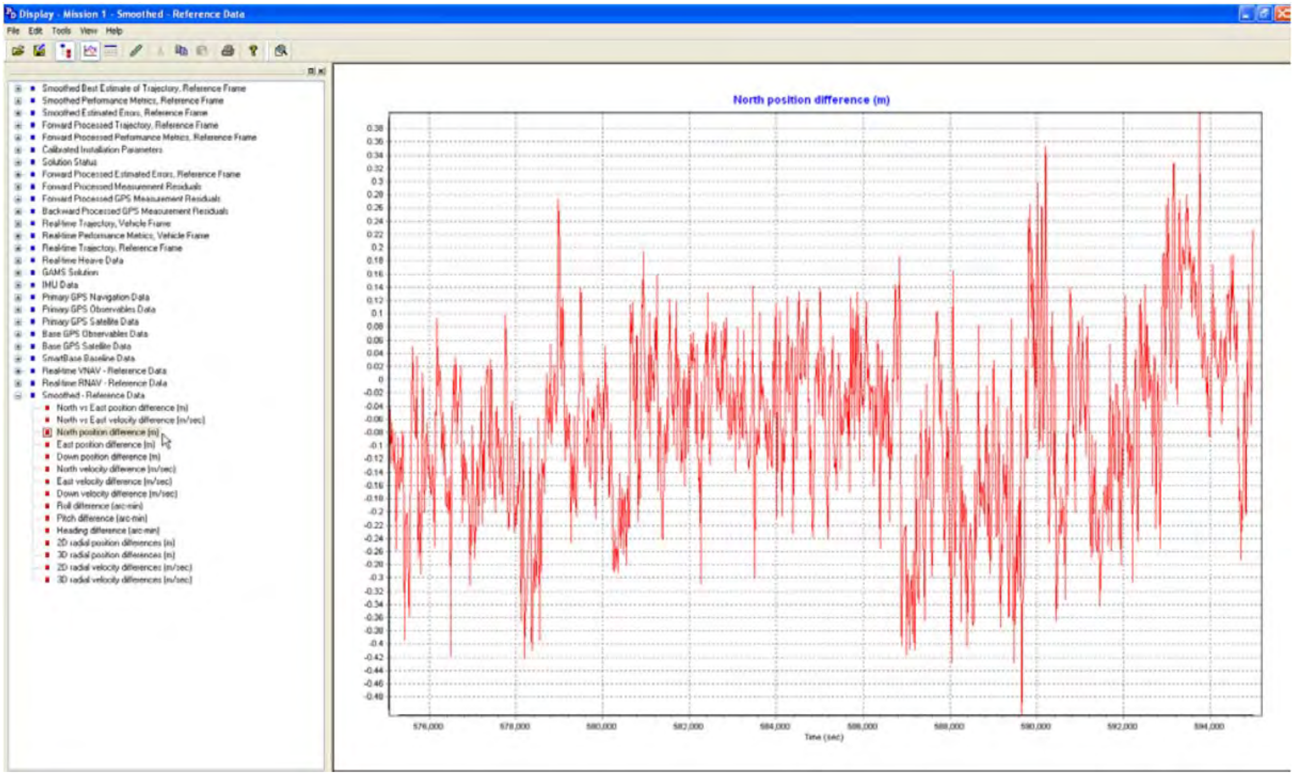
o **Processing mode.** Found under “Solution Status” and then Processing mode. There is a key below this plot that identifies the numerical value of the processing mode. The best solution would be a 0, or Fixed NL. Record the values in the SBET Check sheet.



o **Smoothed- Reference Data**. First, click on Tools, NAVDIF. Under the Reference Data file, browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Extract folder and select vnav_Mission 1.out. Change the Difference Data Output Modulus to 200. Click Difference.

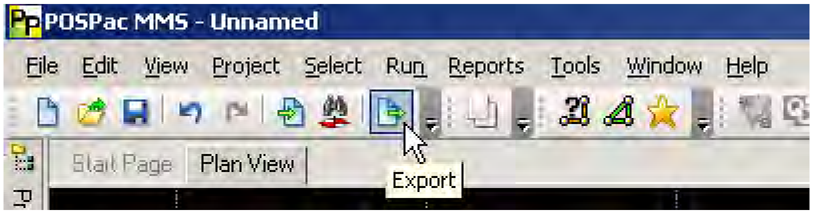


You are differencing the real-time navigation to the SBET solution. When the difference is done, close the NAVDIF box. A new plot will pop up, called Smoothed- Reference Data. Look at the North, East and Down position difference (m) plots. The min/max values for North and East differences should be within +/- 0.50m. The min/max values for the Down difference should be +/- 1m

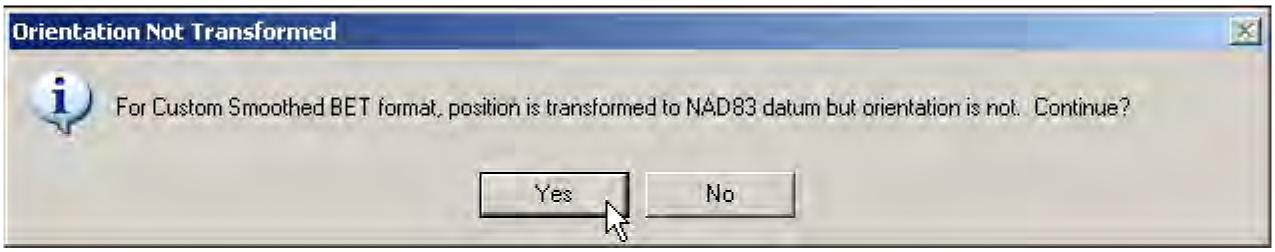


Step Six: Export, Rename SBET and Associated Error File

• Select Project/Export or click the "Export" Icon



• Select Yes to the following.



• Browse to H:\Surveys\HXXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the sbet_Mission 1.out file and rename it to *"Year_JulianDay_Vessel_SBET.out."*

• Browse to H:\Surveys\HXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Proc folder. Locate the smrmsg_Mission 1.out and rename it to *Year_JulianDay_Vessel_RMS.out*

SBET QUALITY CONTROL PROCEDURES

The scope of this document covers how to check and ensure the quality of a SBET.

Section one ensures that you should even begin the extensive review of the SBET, if you perform section one and encounter anything highlighted in red, recommend the file needs reprocessing.

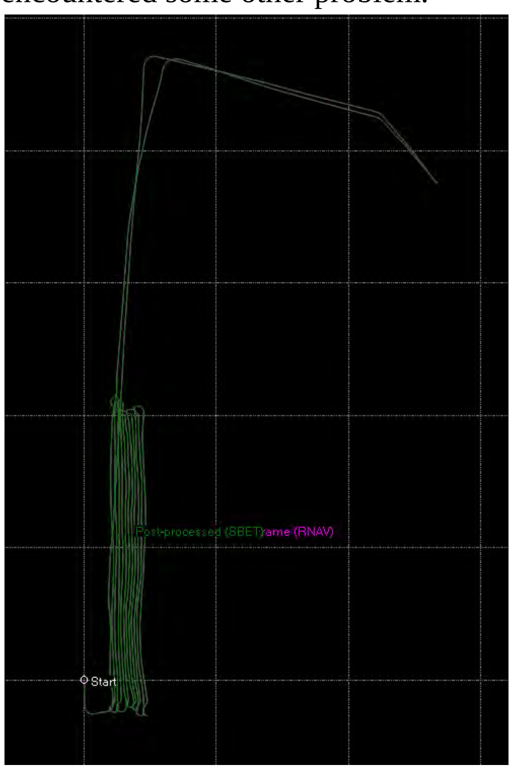
In Section two we observe plots of various components that are, or result in the SBET Solution. Values in red here should be written down and recorded in the QC Log.

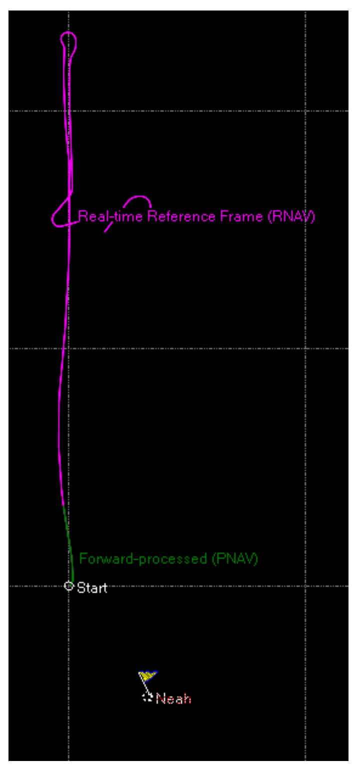
In section three we discuss some advanced troubleshooting methods. For additional reading on the subject, the POSPac Intertial Tools User Manual features some discussion on Solution Quality Assessment.

0.0 SBET File Review

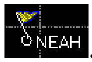
I. Open Project 

- Check that the post-processed solution (Green Solution, PNAV) covers the vast majority of the real-time solution (Pink, RNAV). If you see lots of pink, then it might not have been processed with all the needed days of base station data, or encountered some other problem.



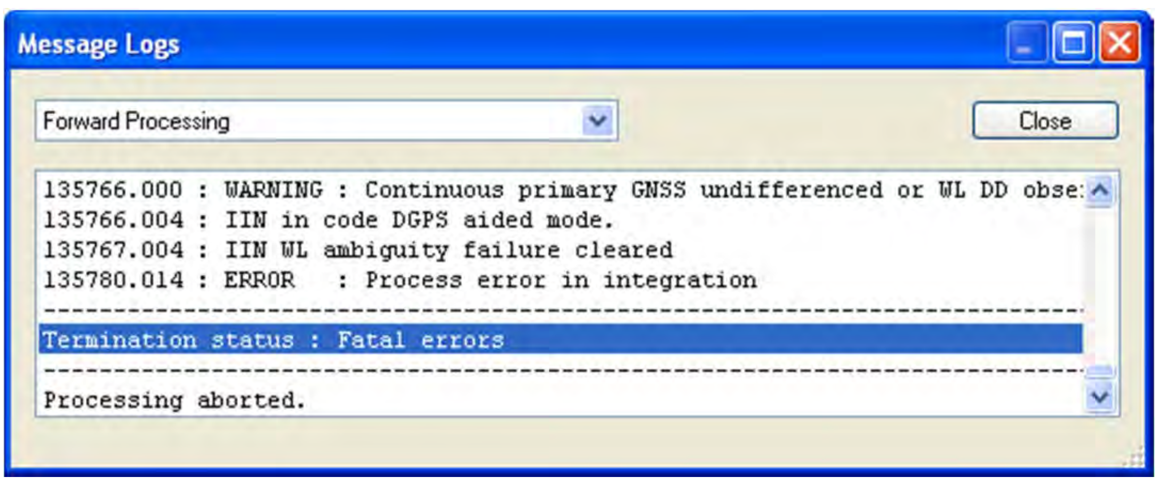


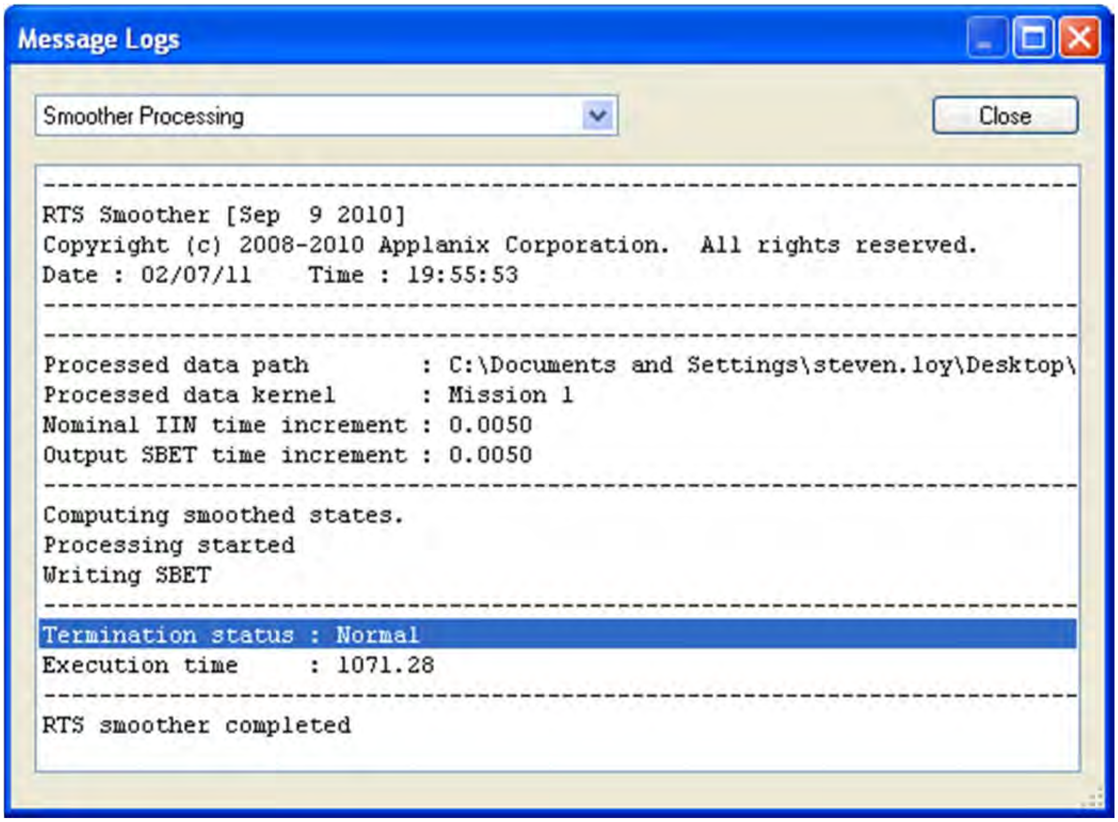
-

- Check if the correct Base Station(s) (Smart and Single base, rinex format) and imported POS (.000) files were used, if any.
    - In Single-base, Find the base station (it has a flag and looks similar to this: 

. You can left-click (drag over it) and see its properties. Ensure it is positioned in the correct location, refer to the HXXXXX_Base_Station file for reference.

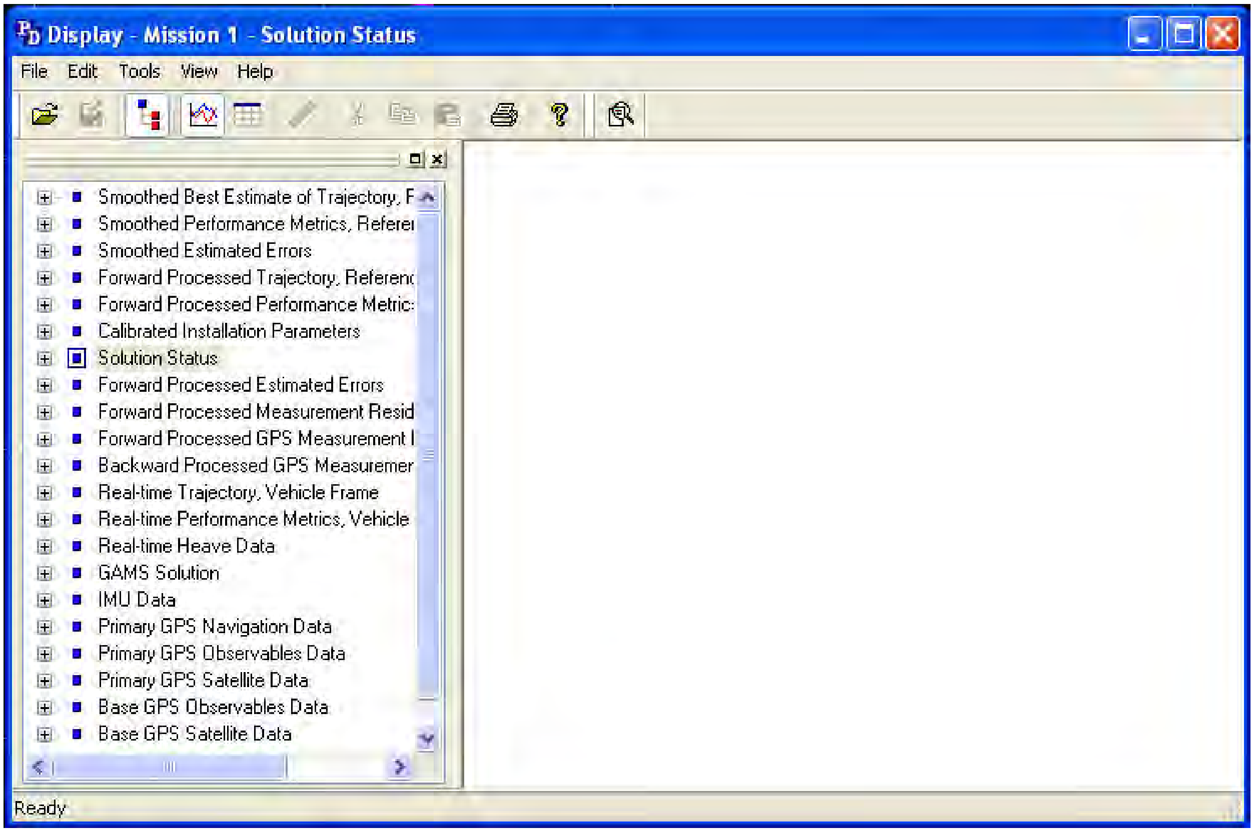
II. Check the **Message Logs** (Toolbar Reports → Message Logs…).

- Check each step, and scroll to the bottom, where you should note if the "Termination status:" is anything other than "Normal. "Fatal errors" would strongly imply a problem with the SBET.
- There should be a "forward" "backward" and "smoother" processing, in addition to other steps. If any of these are missing, a processing error likely occurred.
- Under **POS Data Import**, ensure that the POS status reached Full Navigation, or at Least Fine Align, if it did not, note this.
- Under **IMU Data Continuity** note any reported IMU data gaps. IMU data gaps are typically caused by a data communication failure between IMU nad the POS computer.
- In **Primary/Secondary GNSS Import**, note any decoding errors, likely caused by data communication failures due to corrupted bytes from the GNSS receiver data stream.
- 

- 
Message Logs
Smoother Processing
Close
RTS Smoother [Sep 9 2010]
Copyright (c) 2008-2010 Applanix Corporation. All rights reserved.
Date : 02/07/11 Time : 19:55:53
Processed data path : C:\Documents and Settings\steven.loy\Desktop\
Processed data kernel : Mission 1
Nominal IIN time increment : 0.0050
Output SBET time increment : 0.0050
Computing smoothed states.
Processing started
Writing SBET
Termination status : Normal
Execution time : 1071.28
RTS smoother completed

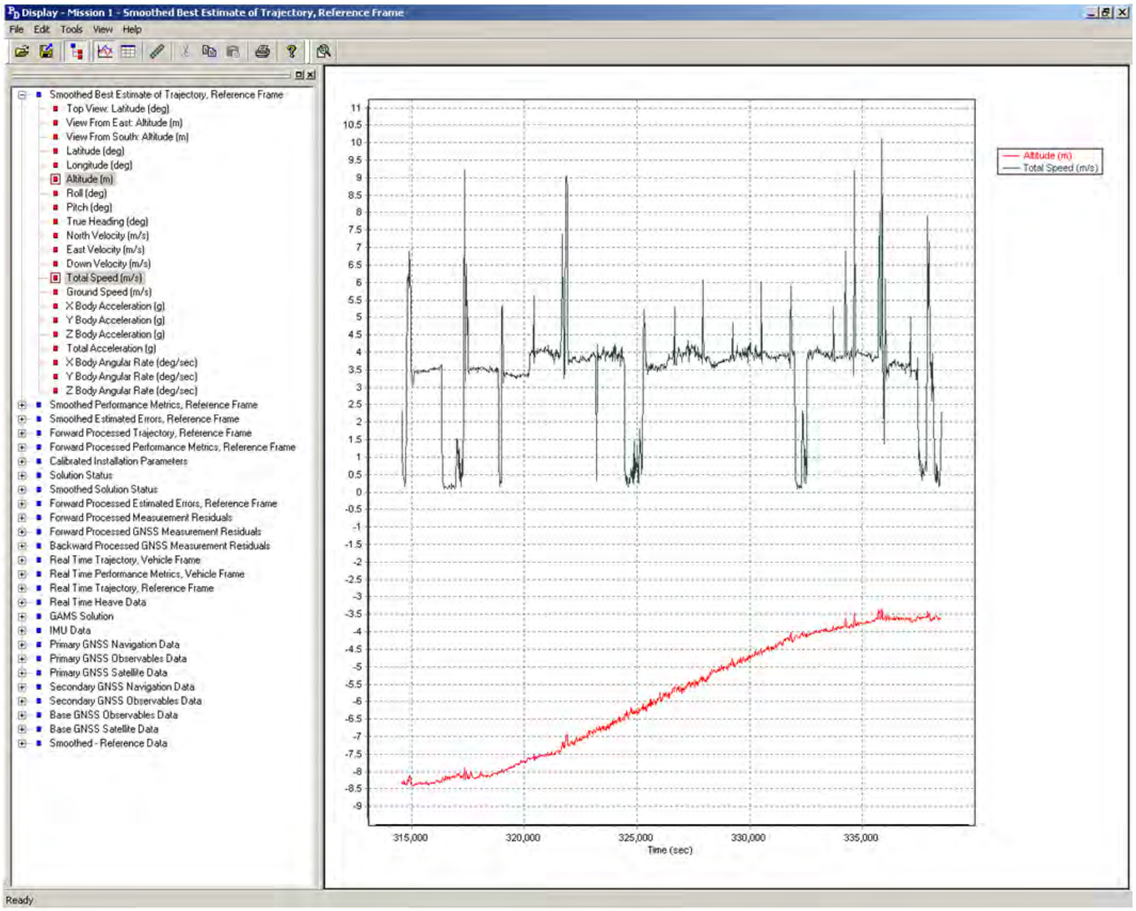
1.0 Plots

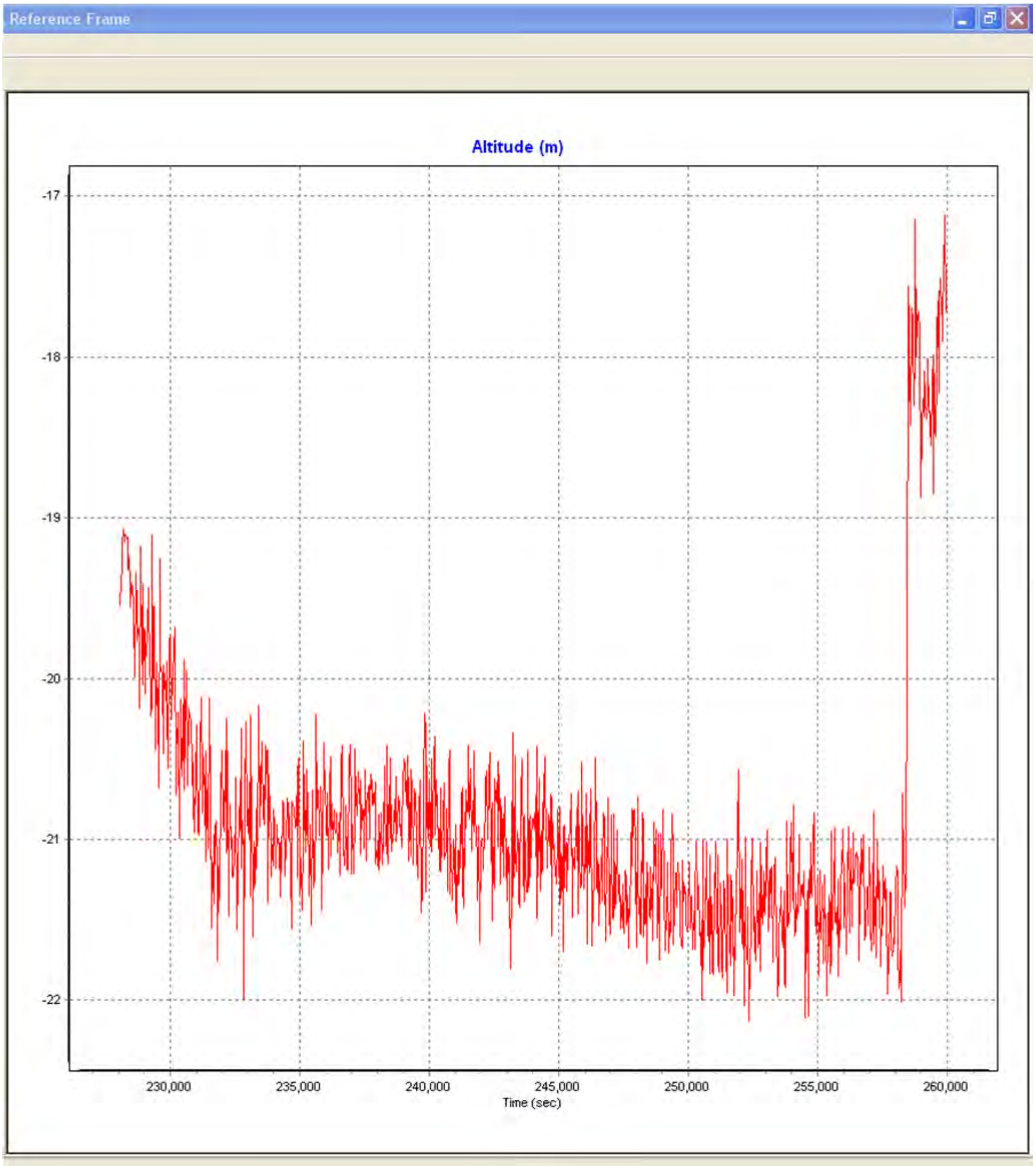
III. Select **Display Plots** either in the Reports tab or the icon  in the tool bar.

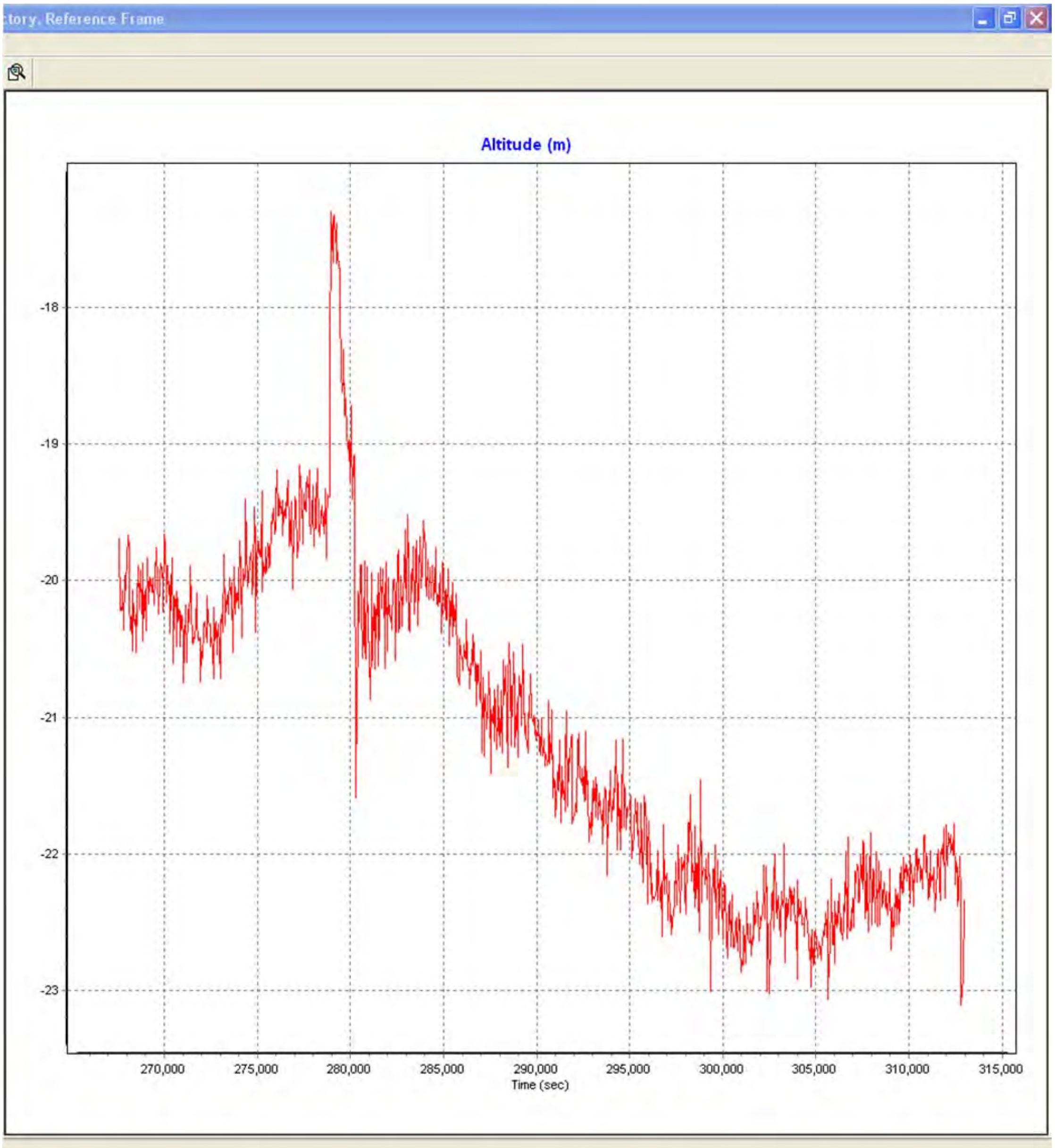


Check the following categories:

- Under ***Smoothed Best Estimate Trajectory, Reference Frame***, check the Altitude for any odd behaviors and compare with Total Speed (m/sec).
    - To display the Altitude and Total Speed together select both and right click → Display Selected…
    - Odd behaviors in the Altitude should correspond to changes in the Total Speed. If not make a comment in the Remarks selection of the Processing Log. Some examples of odd behavior are below

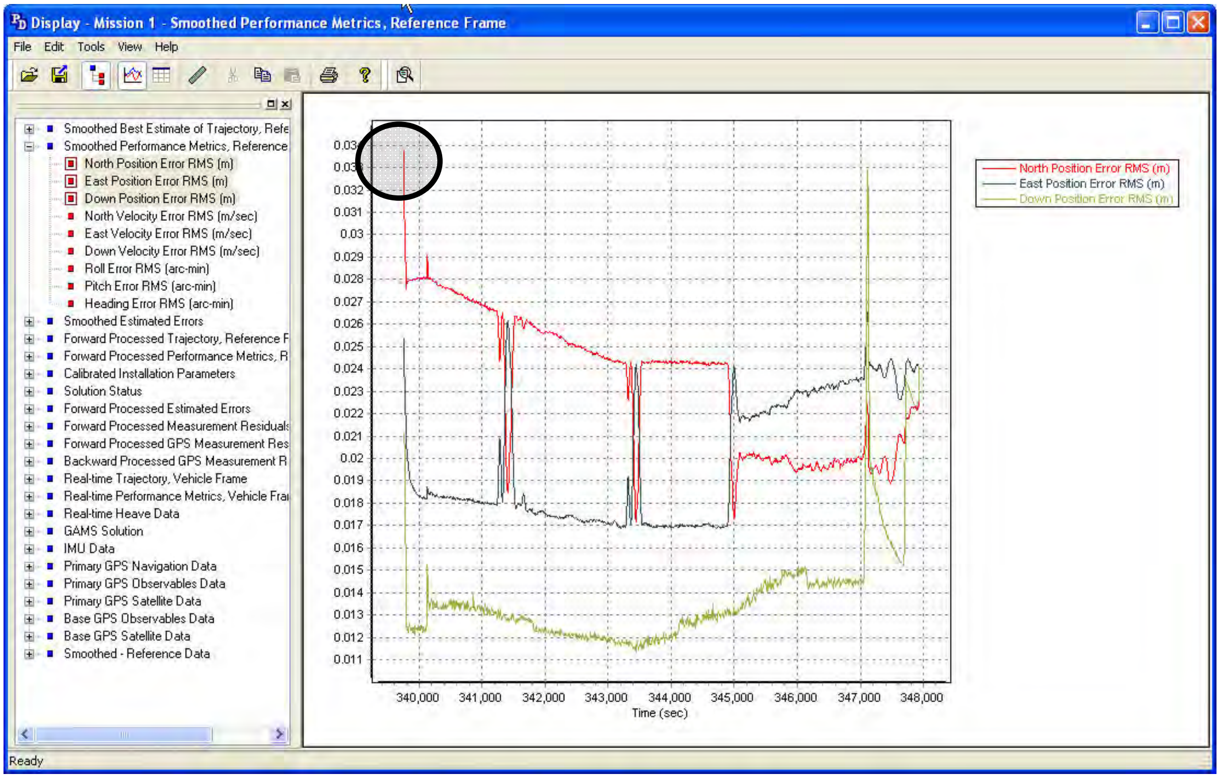

Display - Mission 1 - Smoothed Best Estimate of Trajectory, Reference Frame
File Edit Tools View Help
Smoothed Best Estimate of Trajectory, Reference Frame
Top View: Latitude (deg)
View From East: Altitude (m)
View From South: Altitude (m)
Latitude (deg)
Longitude (deg)
Altitude (m)
Roll (deg)
Pitch (deg)
True Heading (deg)
North Velocity (m/s)
East Velocity (m/s)
Down Velocity (m/s)
Total Speed (m/s)
Ground Speed (m/s)
X Body Acceleration (g)
Y Body Acceleration (g)
Z Body Acceleration (g)
Total Acceleration (g)
X Body Angular Rate (deg/sec)
Y Body Angular Rate (deg/sec)
Z Body Angular Rate (deg/sec)
Smoothed Performance Metrics, Reference Frame
Smoothed Estimated Errors, Reference Frame
Forward Processed Trajectory, Reference Frame
Forward Processed Performance Metrics, Reference Frame
Calibrated Installation Parameters
Solution Status
Smoothed Solution Status
Forward Processed Estimated Errors, Reference Frame
Forward Processed Measurement Residuals
Forward Processed GNSS Measurement Residuals
Backward Processed GNSS Measurement Residuals
Real Time Trajectory, Vehicle Frame
Real Time Performance Metrics, Vehicle Frame
Real Time Trajectory, Reference Frame
Real Time Heave Data
GAMS Solution
IMU Data
Primary GNSS Navigation Data
Primary GNSS Observables Data
Primary GNSS Satellite Data
Secondary GNSS Navigation Data
Secondary GNSS Observables Data
Base GNSS Observables Data
Base GNSS Satellite Data
Smoothed - Reference Data
Altitude (m)
Total Speed (m/s)
315,000
320,000
325,000
330,000
335,000
Time (sec)
Ready


Reference Frame
Altitude (m)
-17
-18
-19
-20
-21
-22
230,000
235,000
240,000
245,000
250,000
255,000
260,000
Time (sec)

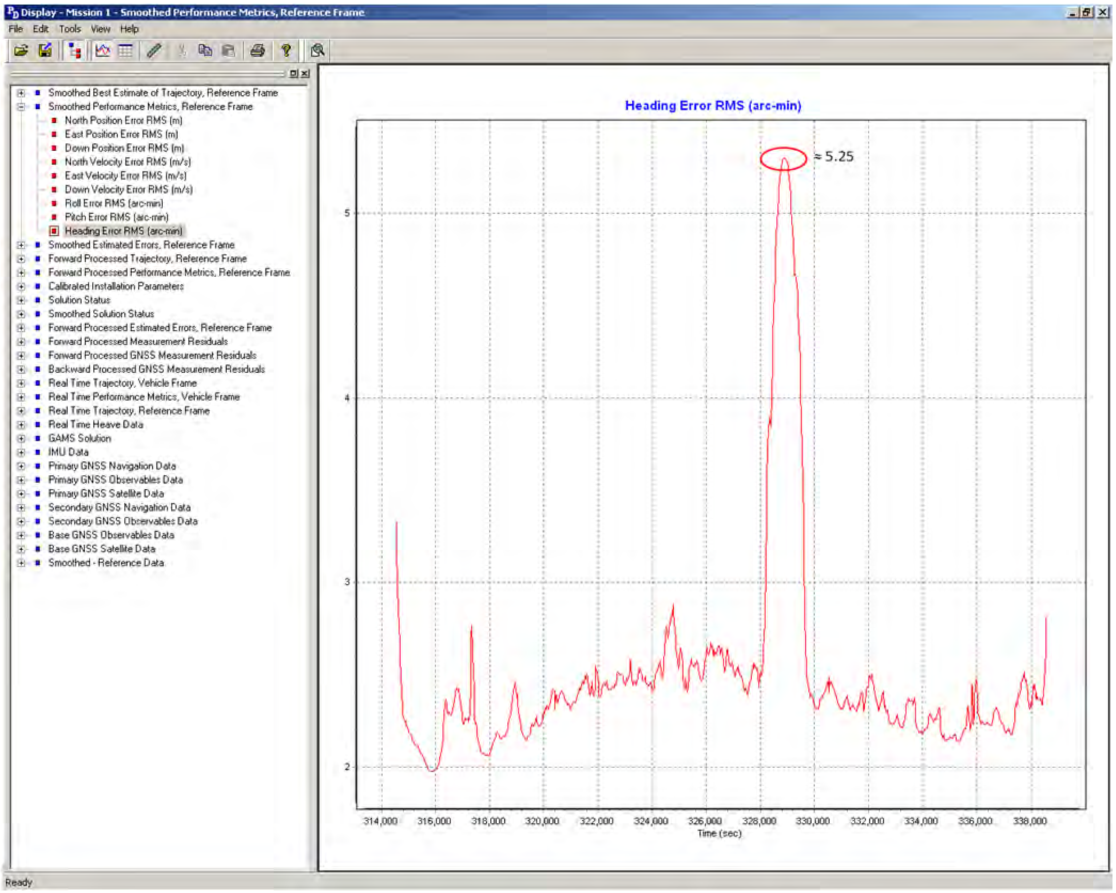


- Jumps in altitude as shown above should be noted and logged. Such offsets will cause problems if the data is used to produce ellipsoidally referenced surfaces. Jumps like this can also be highly indicative of other positioning problems.

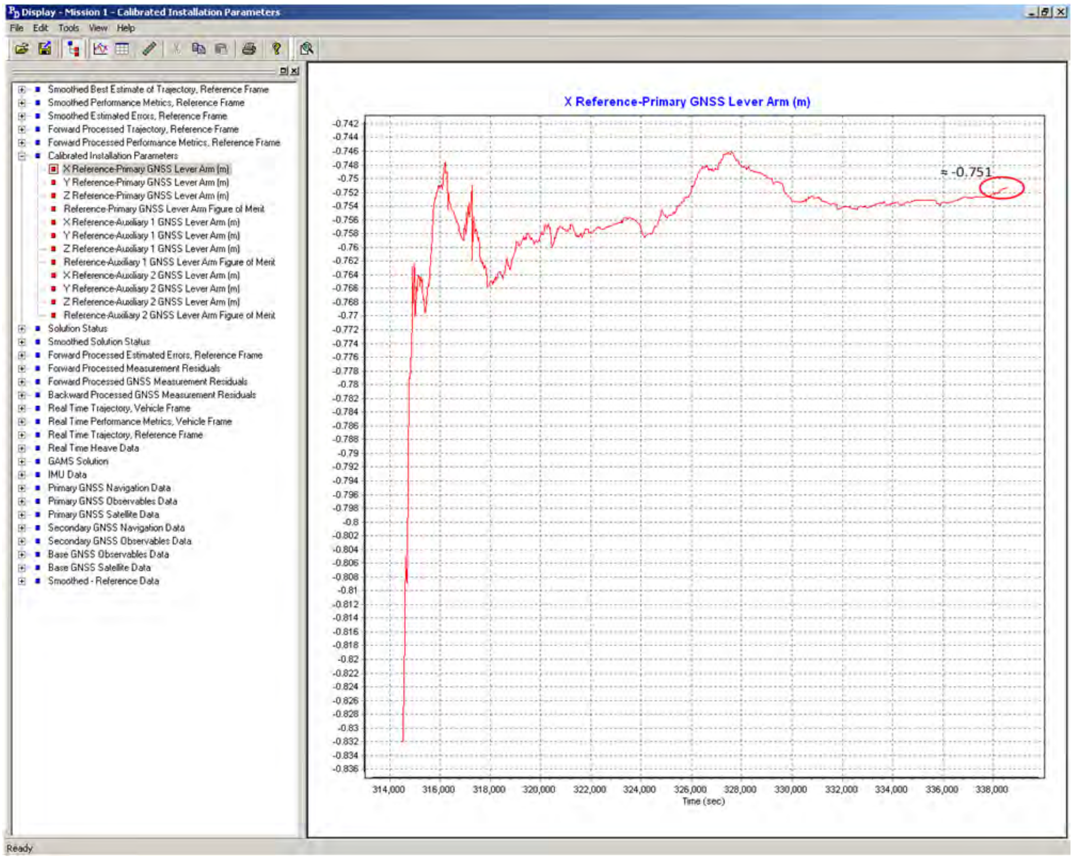
- In the ***Smoothed Performance Metrics, Reference Frame***, select and display the following simultaneously: North Position Error RMS (m), East Position Error RMS (m), and Down Position Error RMS (m).



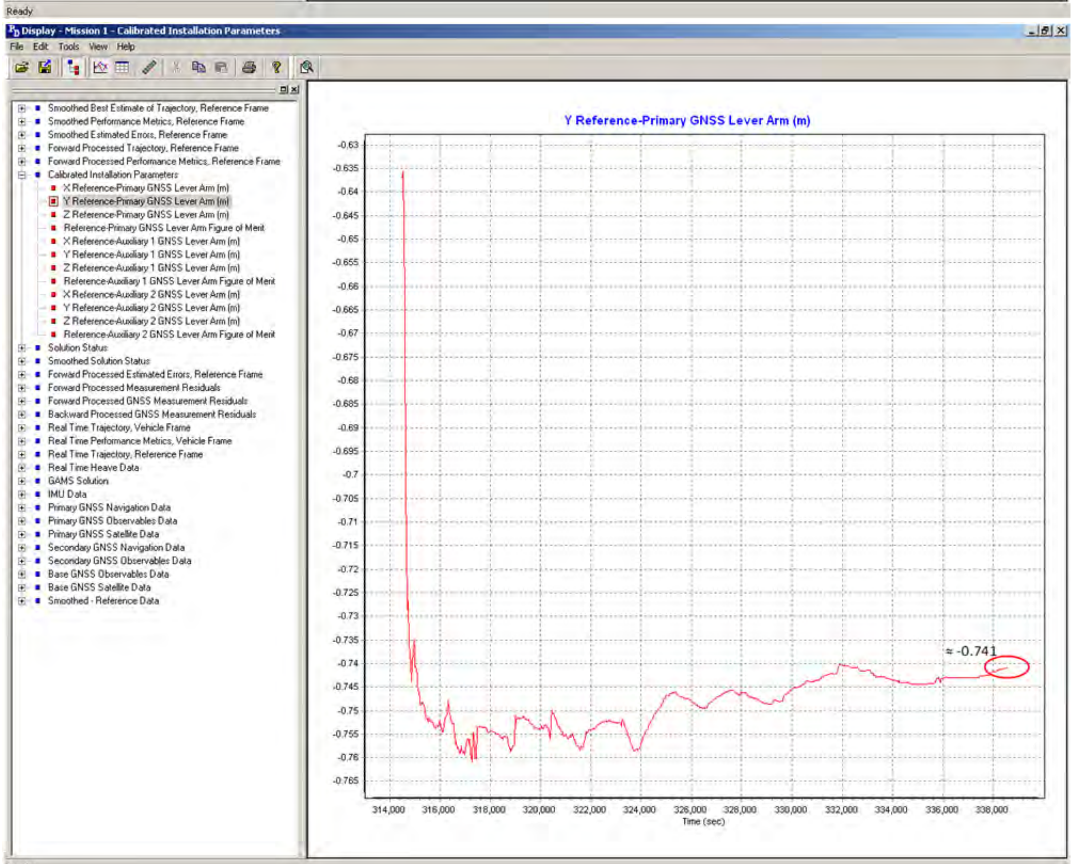
- Excluding the very beginning and very end of the day, **record the highest error for each of the three in the Processing Log as the H/V value.**
- If the value exceeds 7 cm record in the Remarks selection of the Processing Log.
- Record the peak RMS values for Pitch, Roll, and Heading Error.



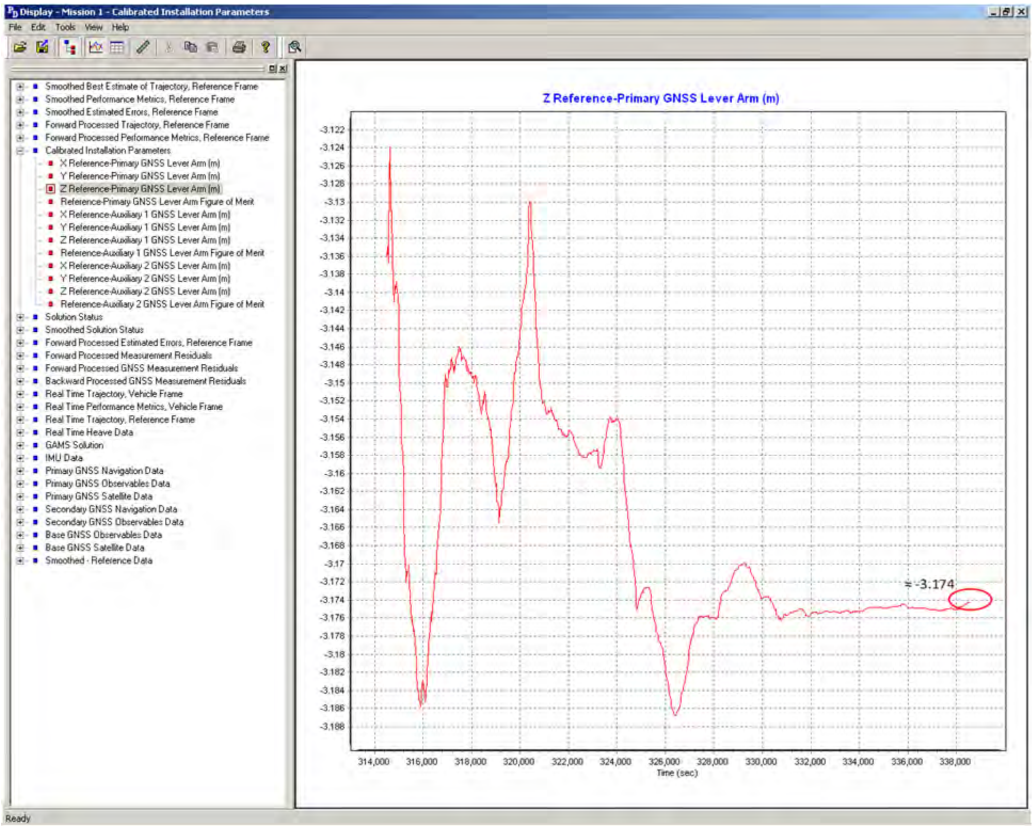
- ***Smoothed Estimated Errors***
    - **Record the x , y, and z accelerometer bias values**
- For ***Calibrated Installation Parameters***, **record in the Processing Log the final positions for: X Reference-Primary GPS Lever Arm (m), Y Reference-Primary GPS Lever Arm (m), and the Z Reference-Primary GPS Lever Arm (m).**
    - For each day within a vessel the values should be similar respectively to each other.
    - Record the Reference-Primary GNSS Lever Arm Figure of Merit value at the end of the solution, it should be 100.

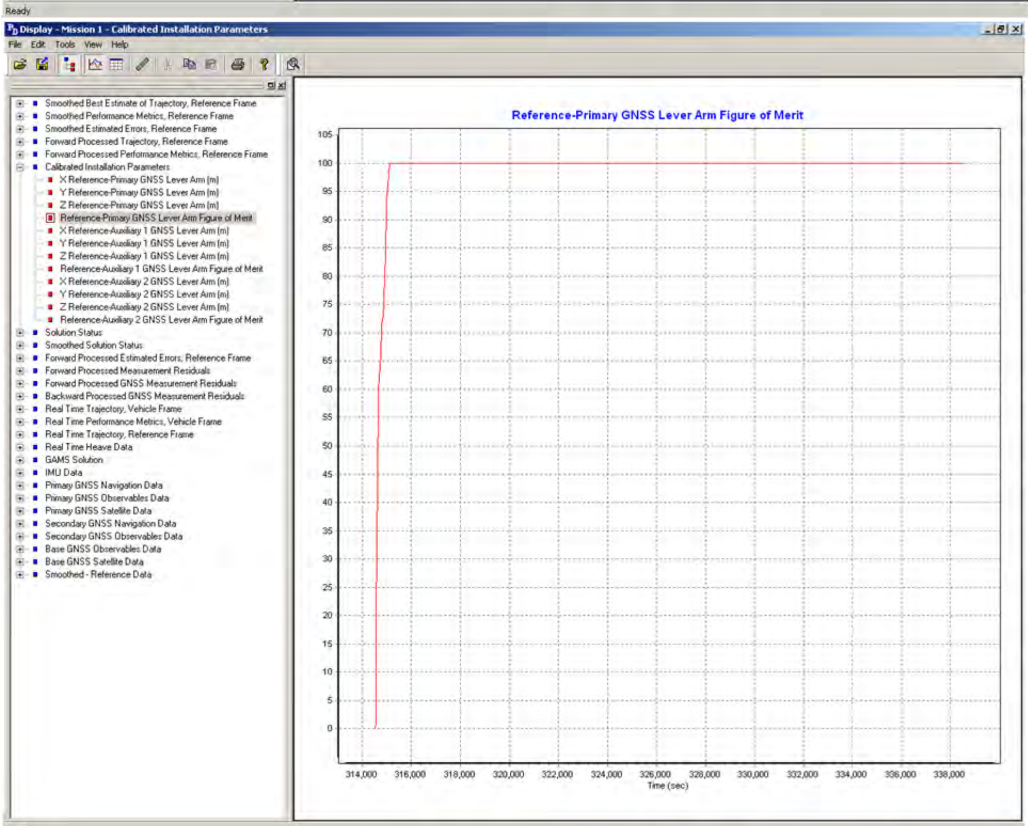

Display - Mission 1 - Calibrated Installation Parameters
X Reference-Primary GNSS Lever Arm (m)
≈ -0.751
Time (sec)
Ready

-


Display - Mission 1 - Calibrated Installation Parameters
Y Reference-Primary GNSS Lever Arm (m)
≈ -0.741
Time (sec)
Ready

-

- 

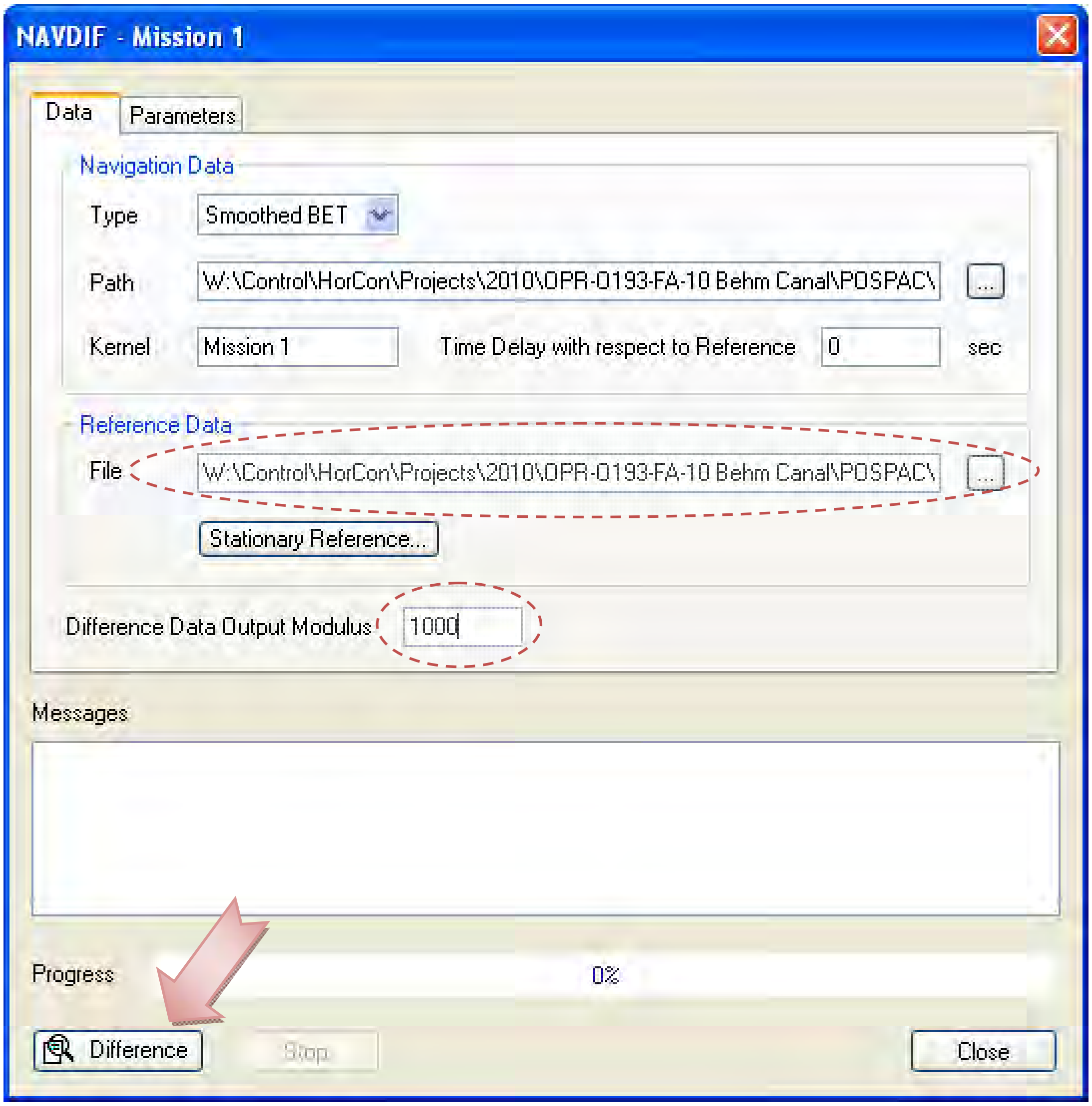
- 

- Under ***Solution Status***, take note of the following subcategories:

    - Number of SVs: log the minimum number of SVs observed during the solution.
        - PDOP: record the highest observed PDOP value. Values less than 3 are preferred The number of satellites and the PDOP are related. If the satellite count drops below 5, then the PDOP value will exceed 3.
    - Baseline length (m), this is your distance from the base station, record the highest value encountered. If the value exceeds 20,000 meters in single base mode, problems are more prone to occur.
    - Processing mode: **record the solution in the Processing Log using one or a combination of values from the Processing mode key.**

    Processing mode: 0 = Fixed NL, 1 = Fixed WL, 2 = Float, 3 = DGPS, 4 = C/A, 5 = GPS Nav, 6 = DR

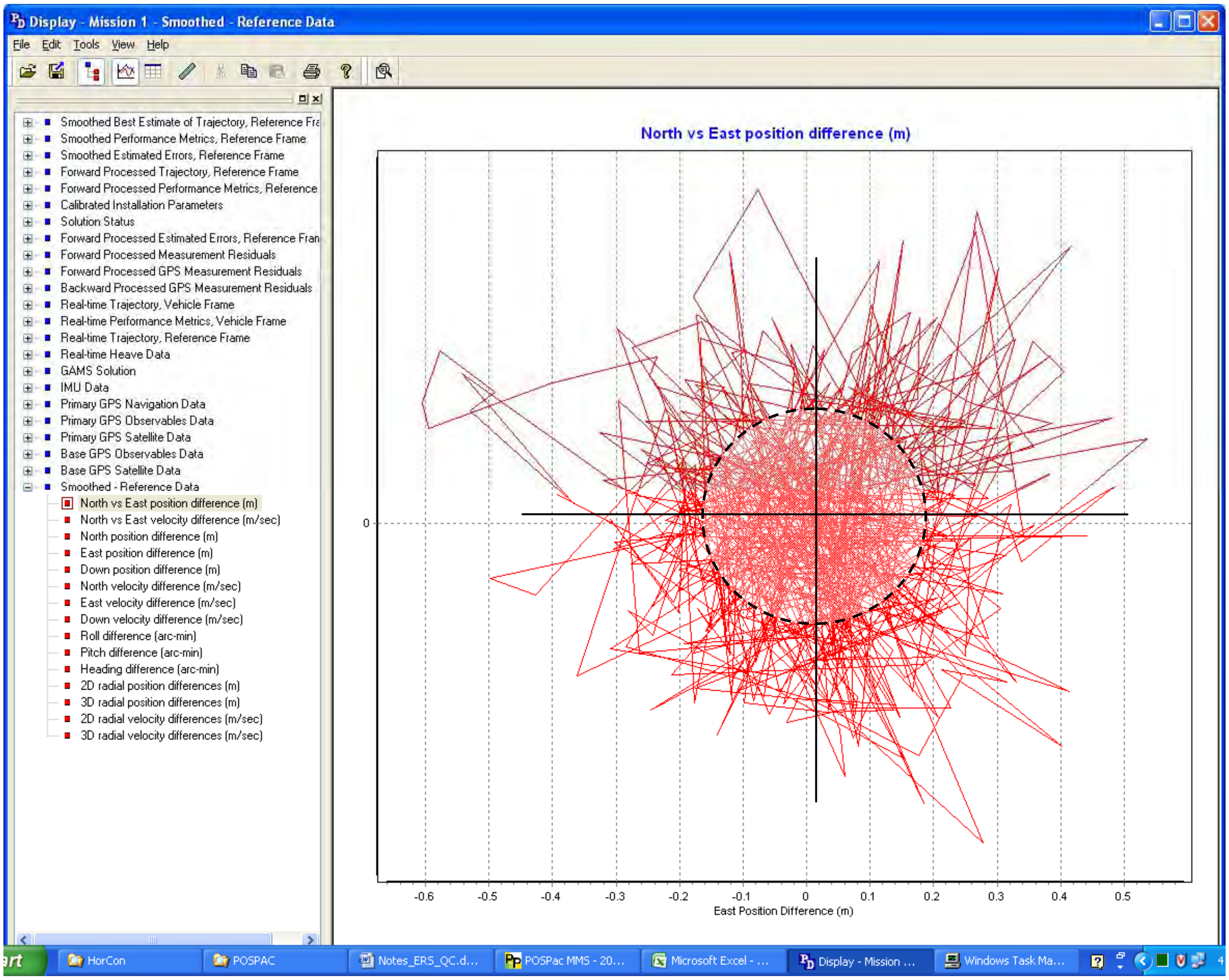
    - Only add 1, 2, or 3 etc besides zero if multiple spikes or the line stays at that level for a while
- ***GAMS Solution***
    - Computed A-B antenna separation (m). Take mental note, don't need to write anything down.
- ***Smoothed – Reference Data*****:** In the tool bar select Tools→NAVDIF or select the icon , and a separate window will open.

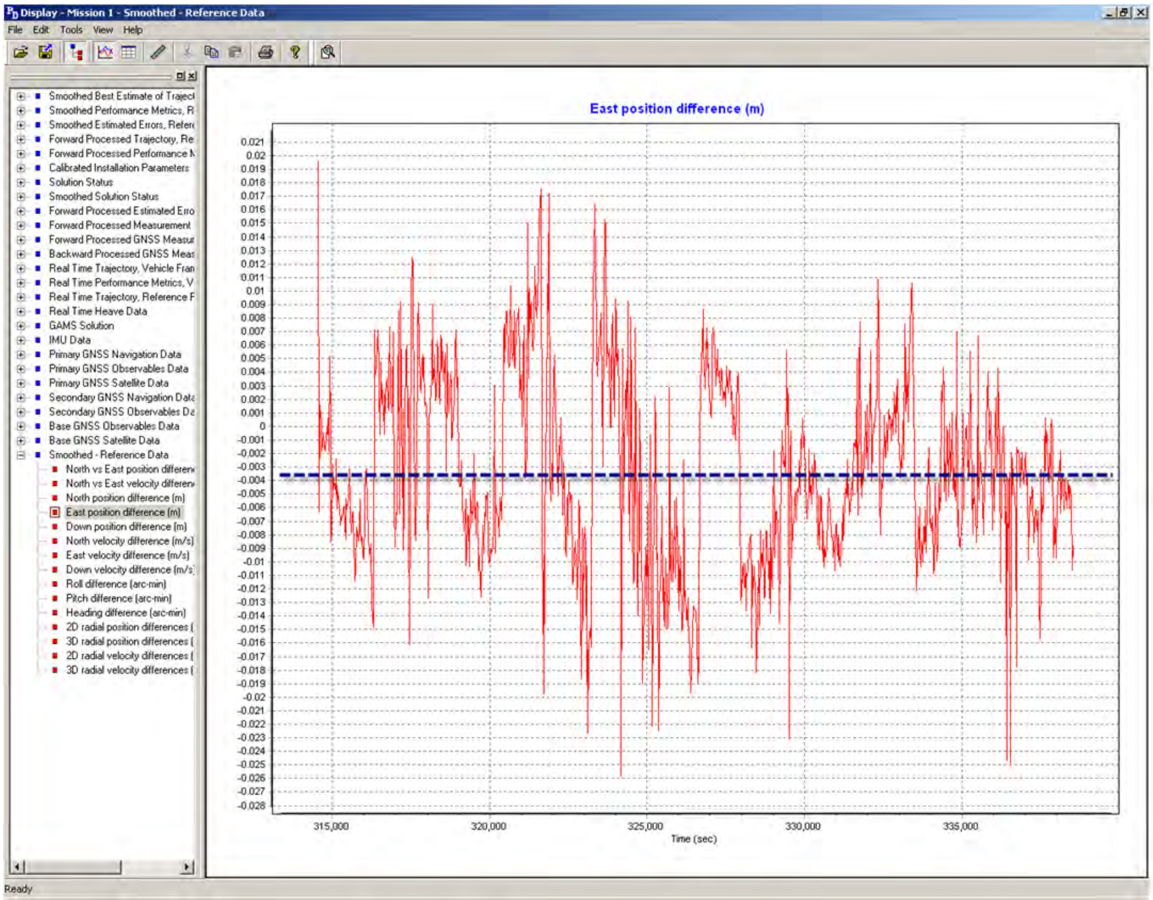


In the *Data* tab, under the *Reference Data* section, browse to: W:\Control\HorCon\Projects\200X*Project*\POSPAC\HXXXXX\HXXXXX_DDD\HXXXXX_VVVV_DDD\Mission 1\Extract\vnav_Mission 1.out.

Under *Reference Data* Set the *Data Output Modulus* to *1000*. Under the Reference Data section and click Difference. Once the process is complete, close the NAVDIF window. A new category (*Smoothed – Reference Data*) will appear.

- For the North vs. East position difference (m) You should be looking at an approximately round scatter plot – zoom into the most dense area of data (near 0/0 on the graph) approximate the scatter plot center's offset from 0/0 on the graph. **Note in the Processing Log the N/S and E/W offsets of the centermost location from zero.**
- Alternatively you can look at the North and East Position Differences individually and infer an individual average.

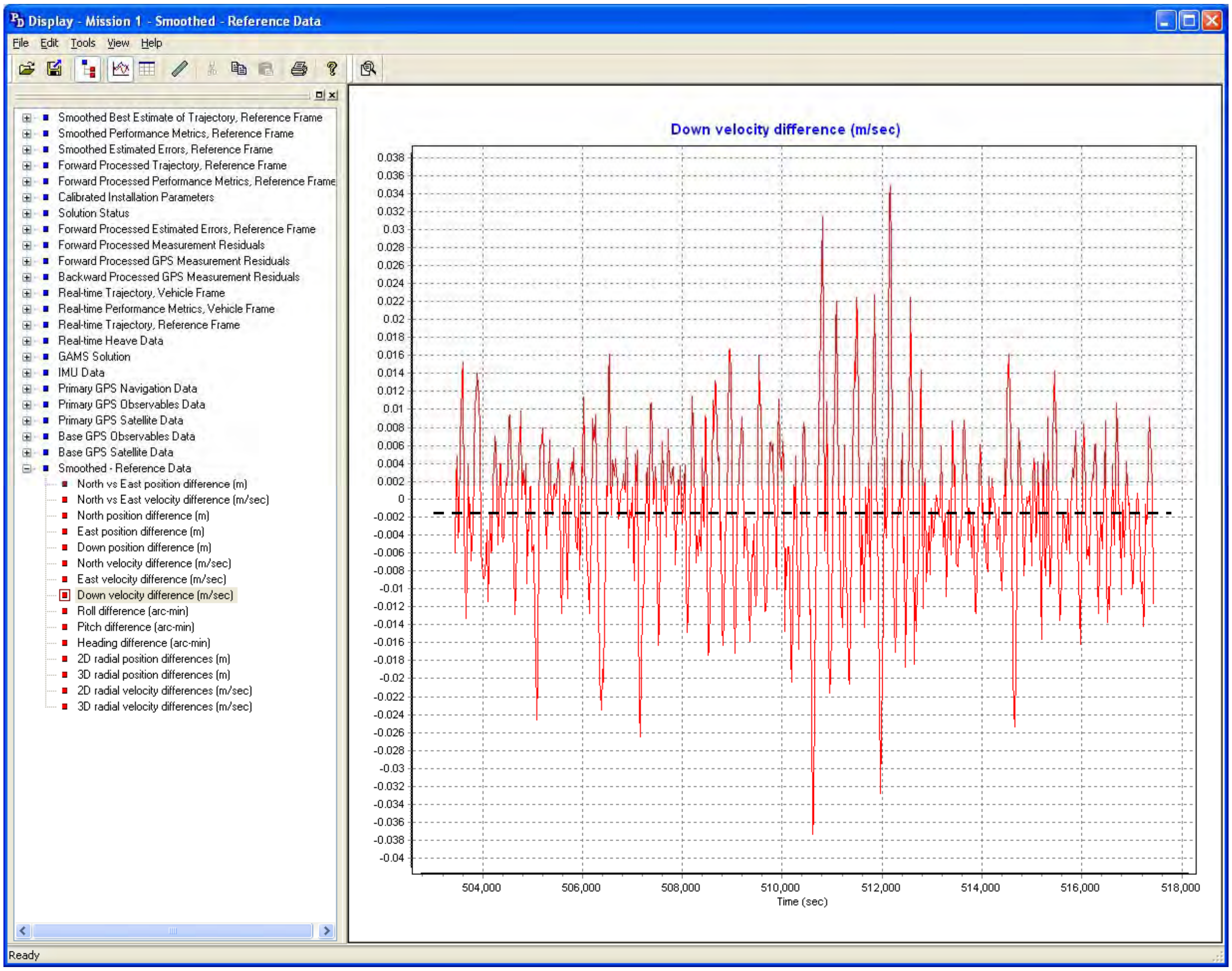

Display - Mission 1 - Smoothed - Reference Data
File Edit Tools View Help
Smoothed Best Estimate of Trajectory, Reference Fra
Smoothed Performance Metrics, Reference Frame
Smoothed Estimated Errors, Reference Frame
Forward Processed Trajectory, Reference Frame
Forward Processed Performance Metrics, Reference
Calibrated Installation Parameters
Solution Status
Forward Processed Estimated Errors, Reference Fran
Forward Processed Measurement Residuals
Forward Processed GPS Measurement Residuals
Backward Processed GPS Measurement Residuals
Real-time Trajectory, Vehicle Frame
Real-time Performance Metrics, Vehicle Frame
Real-time Trajectory, Reference Frame
Real-time Heave Data
GAMS Solution
IMU Data
Primary GPS Navigation Data
Primary GPS Observables Data
Primary GPS Satellite Data
Base GPS Observables Data
Base GPS Satellite Data
Smoothed - Reference Data
North vs East position difference (m)
North vs East velocity difference (m/sec)
North position difference (m)
East position difference (m)
Down position difference (m)
North velocity difference (m/sec)
East velocity difference (m/sec)
Down velocity difference (m/sec)
Roll difference (arc-min)
Pitch difference (arc-min)
Heading difference (arc-min)
2D radial position differences (m)
3D radial position differences (m)
2D radial velocity differences (m/sec)
3D radial velocity differences (m/sec)
North vs East position difference (m)
0
-0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
East Position Difference (m)
HorCon
POSPAC
Notes_ERS_QC.d...
POSPac MMS - 20...
Microsoft Excel - ...
Display - Mission ...
Windows Task Ma...



Display - Mission 1 - Smoothed - Reference Data
File Edit Tools View Help
Smoothed Best Estimate of Traject
Smoothed Performance Metrics, R
Smoothed Estimated Errors, Refere
Forward Processed Trajectory, Re
Forward Processed Performance M
Calibrated Installation Parameters
Solution Status
Smoothed Solution Status
Forward Processed Estimated Erro
Forward Processed Measurement
Forward Processed GNSS Measur
Backward Processed GNSS Meas
Real Time Trajectory, Vehicle Fran
Real Time Performance Metrics, V
Real Time Trajectory, Reference F
Real Time Heave Data
GAMS Solution
IMU Data
Primary GNSS Navigation Data
Primary GNSS Observables Data
Primary GNSS Satellite Data
Secondary GNSS Navigation Data
Secondary GNSS Observables Da
Base GNSS Observables Data
Base GNSS Satellite Data
Smoothed - Reference Data
North vs East position differen
North vs East velocity differen
North position difference (m)
East position difference (m)
Down position difference (m)
North velocity difference (m/s)
East velocity difference (m/s)
Down velocity difference (m/s)
Roll difference (arc-min)
Pitch difference (arc-min)
Heading difference (arc-min)
2D radial position differences (
3D radial position differences (
2D radial velocity differences (
3D radial velocity differences (
East position difference (m)
0.021
0.02
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
-0.007
-0.008
-0.009
-0.01
-0.011
-0.012
-0.013
-0.014
-0.015
-0.016
-0.017
-0.018
-0.019
-0.02
-0.021
-0.022
-0.023
-0.024
-0.025
-0.026
-0.027
-0.028
315,000
320,000
325,000
330,000
335,000
Time (sec)
Ready

Down Position Difference (m)

- **Record in the Processing Log the approximate trend line for the *Down position difference (m)*.**
    - o If unable to determine record as ‘na’



- ***2D radial position differences*** (m)- generally below 2m is okay.
- ***3D radial position differences*** (m)- generally below 3m is okay.
- For any abnormally large spikes, reference the Real-Time Performance Metrics, North, East and Down Position Errors and compare with the radial position difference time when there are large jumps in the position differences. If the radial spike corresponds to any spikes in the Real-time positions, we can assume the error occurred in real time and was not introduced by the post-processing.

IV. **In the Processing Log note in the Recommendation one of the following**:

- Apply
- Apply with inspection
- Needs Trouble shooting

2.0 Advanced Troubleshooting and considerations

If you encounter any major issues, one of the key questions will be determining if the vessel was even logging data during the time of the error. Using a utility (W:\Control\HorCon\Utilities\ GPS_Seconds.xlsx) we can easily convert the time displayed on a plot or in the overview screen into a time that we can compare to .hsx logging times (or vice versa). If the error is within logging times, inspect the lines manually and using directed editing techniques.

Files can be reprocessed in POSPAC using alternative processing methods (PPP, Smartbase, Singlebase) and without using batch and have the resultant solutions compared using plots, or navdiff the resultant sbets. Start and end times of processing can also be altered to not process certain parts of the file.

Errors apparent in a given vessel can be compared across the same vessel during different days, or compared to other vessels at the same time. 3-4 vessels experiencing a similar error at the same time could imply external sources (Atmosphere, satellites, etc), whereas a recurring error on one vessel may be indicative of an internal issue (settings, hardware, software).

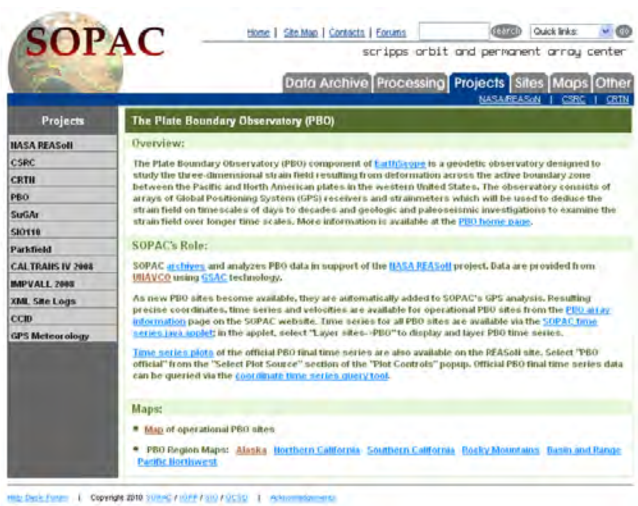
SETTING UP A SMARTBASE NETWORK

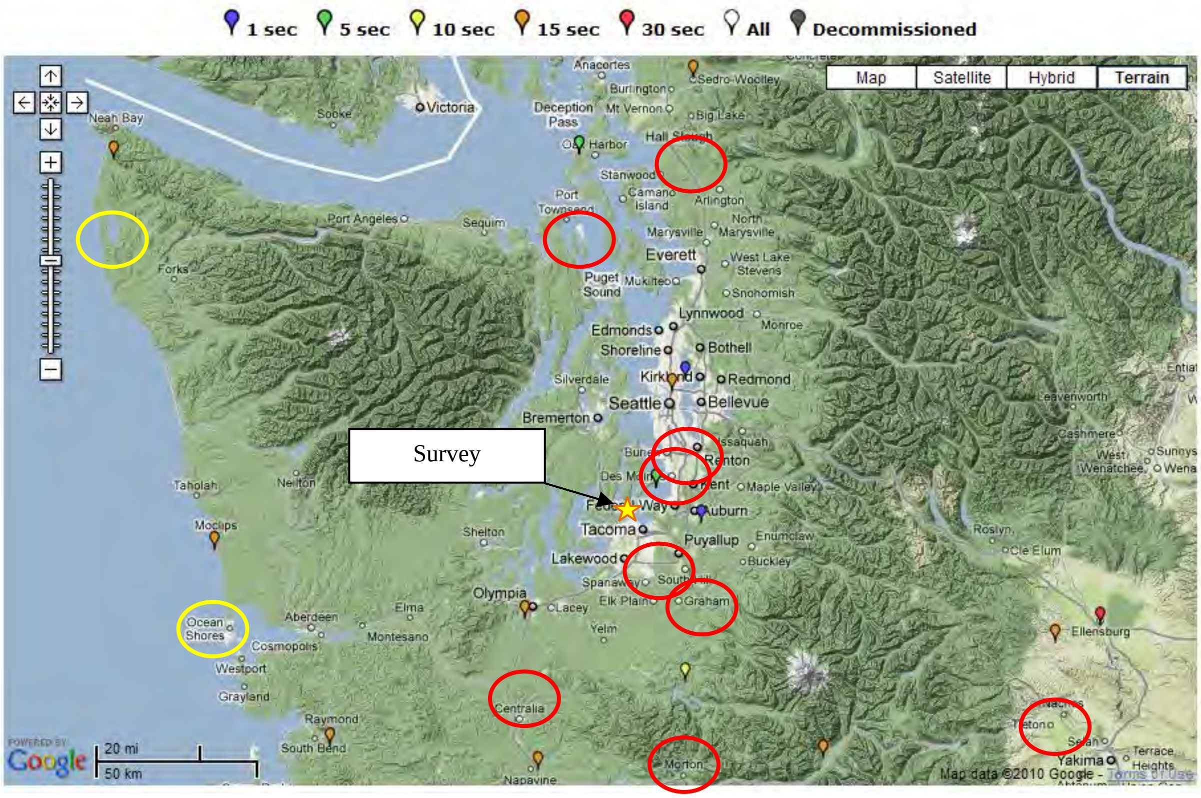
Research Stations

The first question you need to evaluate when trying to plan for a Smart Base project is how many stations are roughly within 200 km of your working grounds? CORS is your best and easiest to use resource if you are working in the lower forty-eight states, so I would start by checking out the following website: http://www.ngs.noaa.gov/CORS/

Ideally you would like six to twelve stations completely surrounding your survey to ensure a strong network if data becomes unavailable from one or two stations throughout your survey. Also, it is best to look for stations with recording intervals of 1 to 15 sec, but 30 sec stations have been used in the past with variable results.

UNAVCO stations are a collection of plate boundary observatory (PBO) locations and also tend to be in useful locations across Alaska. The problem with using these stations, however, is that while CORS stations have NGS Data Sheets and good published positions, the UNAVCO stations tend to have unreliable published positions in ITRF coordinates while we are using NAD 83. Therefore, in order to make use of the UNAVCO or PBO stations, extra steps are required to download data from the stations directly and submit it through OPUS (http://www.ngs.noaa.gov/OPUS/) in order to have a reliable position. Good websites for checking out PBO site locations are both the UNAVCO site (http://pboweb.unavco.org/) and the SCRIPPS Orbit and Permanent Array Center or SOPAC site (http://sopac.ucsd.edu/projects/pbo/).





The thirteen CORS stations selected above all meet the 200 km distance requirement, have recording intervals more frequently than 15 sec, and provide a good geometry, completely surrounding the survey working grounds. However, in the next step where you test the network for good internal consistency and no POSPac position adjustments, the two stations circled in yellow had to be thrown out. With those westernmost stations included, the Smart Base Network was constantly making adjustments.

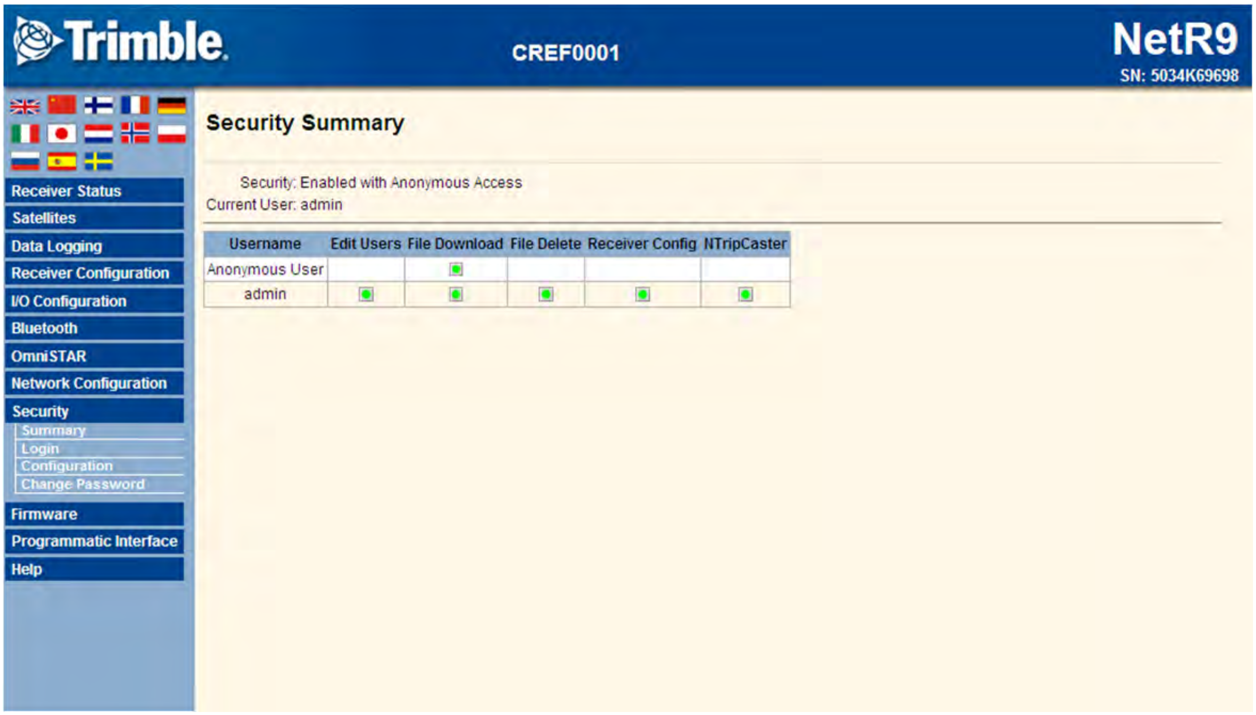
Creating the APPA File

The APPA file is officially titled "APPA_RSDB5.out" and is located in C:\Program Files\Applanix\POSPac MMS 5.4 on your local machine. This file is a listing of all base stations POSPac is looking to download data from. The original file located in the C:\ drive contains nearly five thousand stations from many sources including CORS, UNAVCO, and IGS for example.

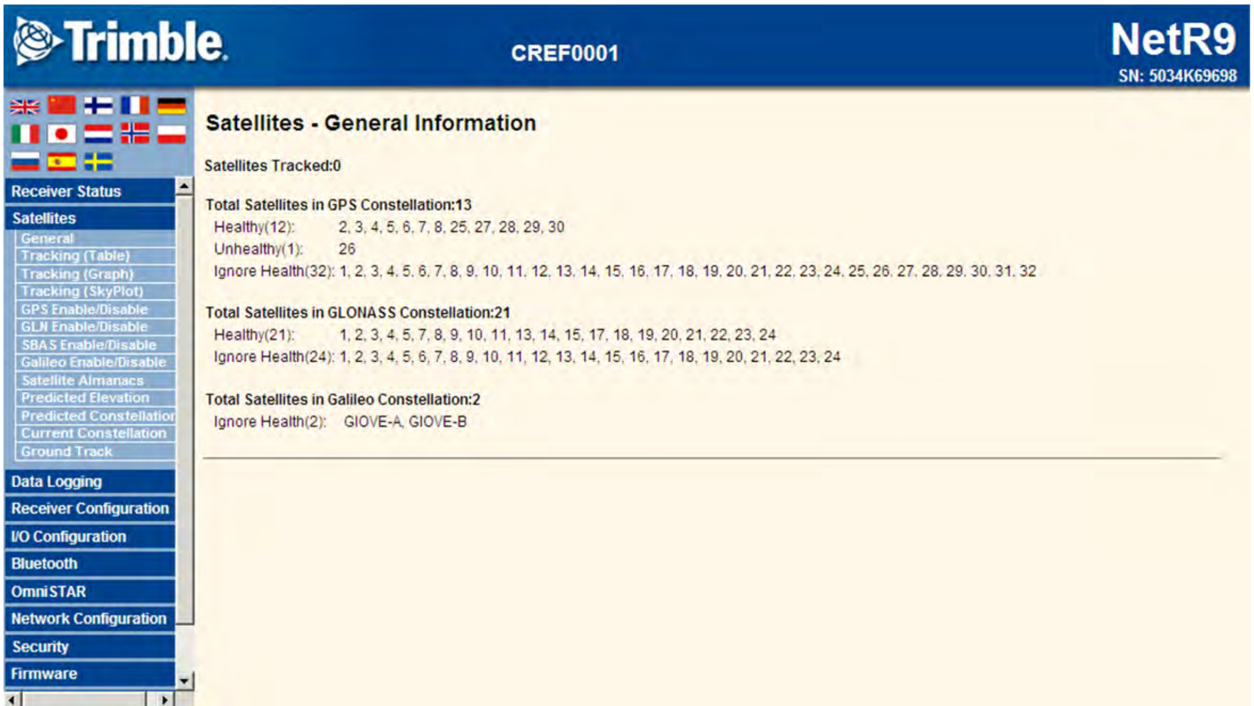
```
$REFERENCE_STATION_DB
Version #2.780 - Applanix Database
szStationName,szStationFullName,eCoordAcc,dXCoord,dYCoord,dZCoord,dXVel,dYVel,dZVel,eDatum,iYear,iMonth,iDay,iUYear,iUMonth,iUDay,iNbOfServices,szGNSS_Services
AC03,AC03,NETWORK_ADJ,-2838819.193,-1518048.841,5487672.821,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC06,AC06,NETWORK_ADJ,-2813462.790,-1566562.172,5487808.681,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC18,AC18,NETWORK_ADJ,-2920684.605,-1536678.566,5439867.229,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC35,AC35,NETWORK_ADJ,-2843219.734,-1589463.280,5465731.435,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC39,AC39,NETWORK_ADJ,-2951218.112,-1543249.832,5421552.480,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC47,AC47,NETWORK_ADJ,-2832479.178,-1466717.825,5505807.916,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AC59,AC59,NETWORK_ADJ,-2900772.334,-1440891.433,5476476.418,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
AV02,AV02,NETWORK_ADJ,-2916880.628,-1458859.181,5463145.147,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
SELD,SELD,NETWORK_ADJ,-2862120.600,-1540664.880,5469360.075,0,0,0,NAD83,2003,1,1,2003,1,1,1,UNAVCO
```

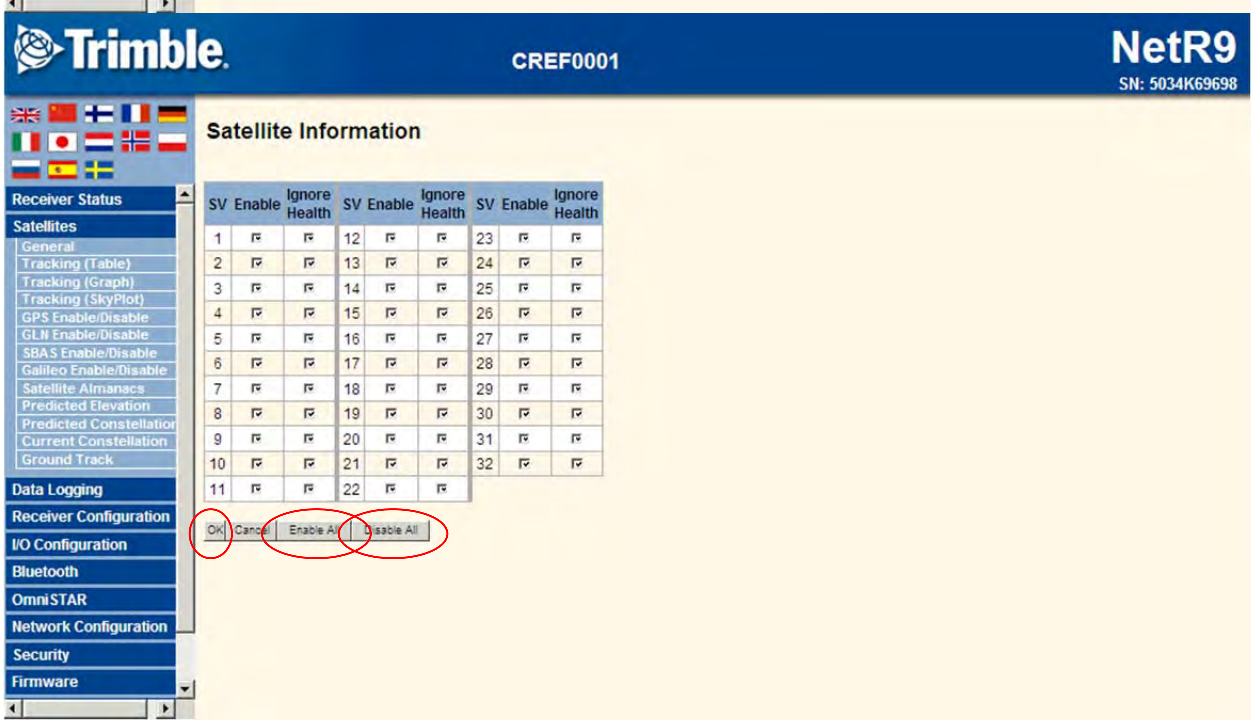
TRIMBLE NetR9 SETUP

Setting up new Trimble NetR9 receivers
Start with a computer (field laptop) which is set-up with appropriate subnet mask and gateway.
Turn on NetR9 receiver, press enter, press down, press enter, **Disable** DHCP, **Enter** appropriate IP address, subnet mask and gateway. **Restart** the receiver.
The computer should now connect to the receiver with the correct IP Address.
Under the security tab select **Enabled with Anonymous Access,** and give the anonymous user **File Download** capabilities. Login as the administrator (User=admin, Password=Password), **Change Password** to Admin.

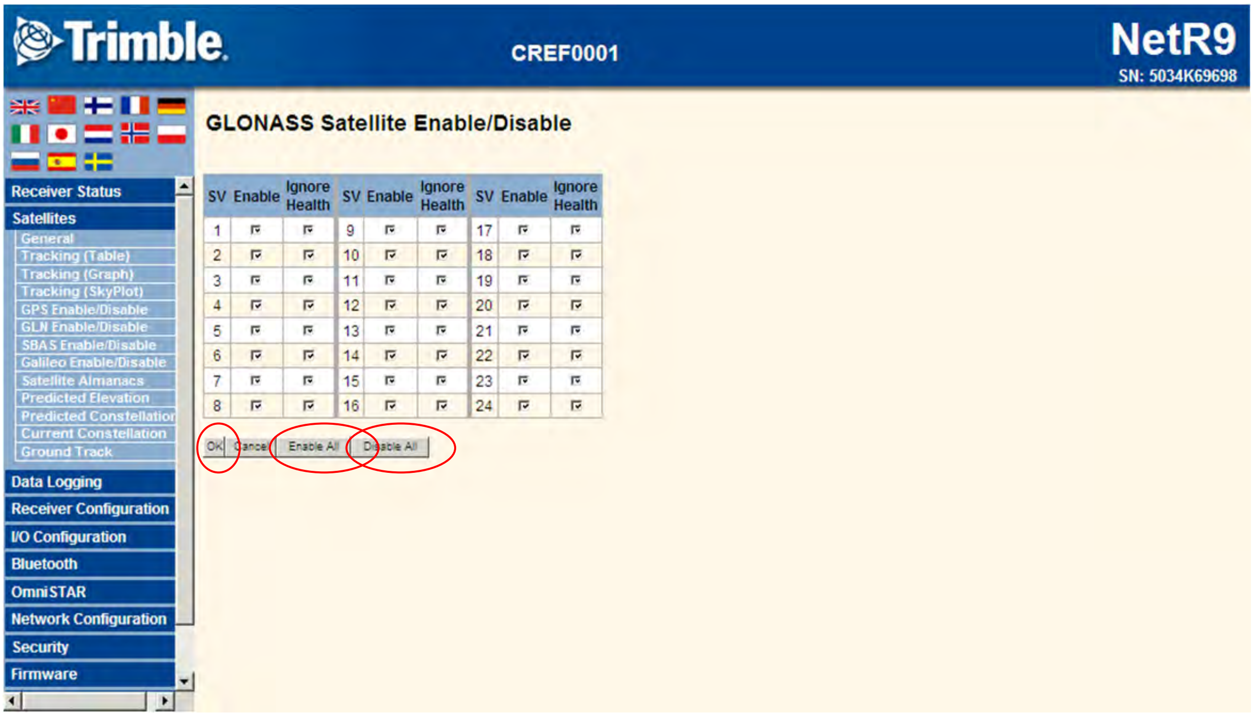


Start at the top and follow the screengrabs:
Ignore Receiver Status
Under Satellites

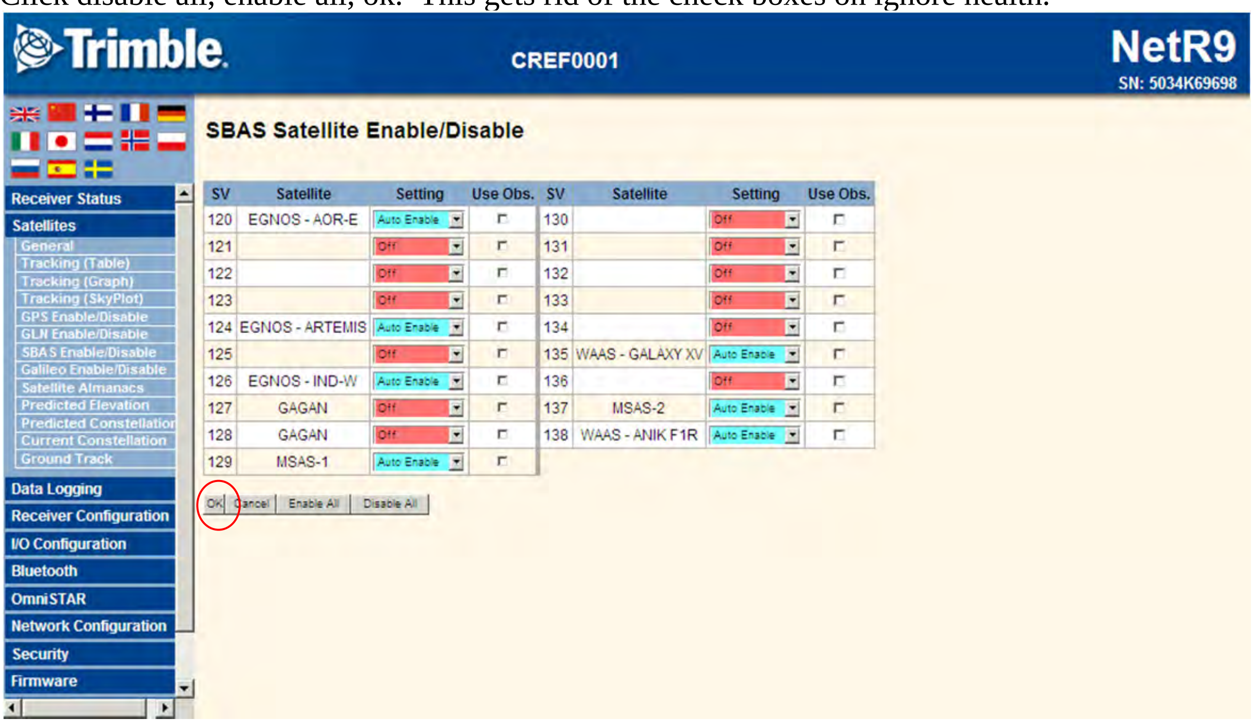




Click disable all, enable all, ok. This gets rid of the check boxes on ignore health.



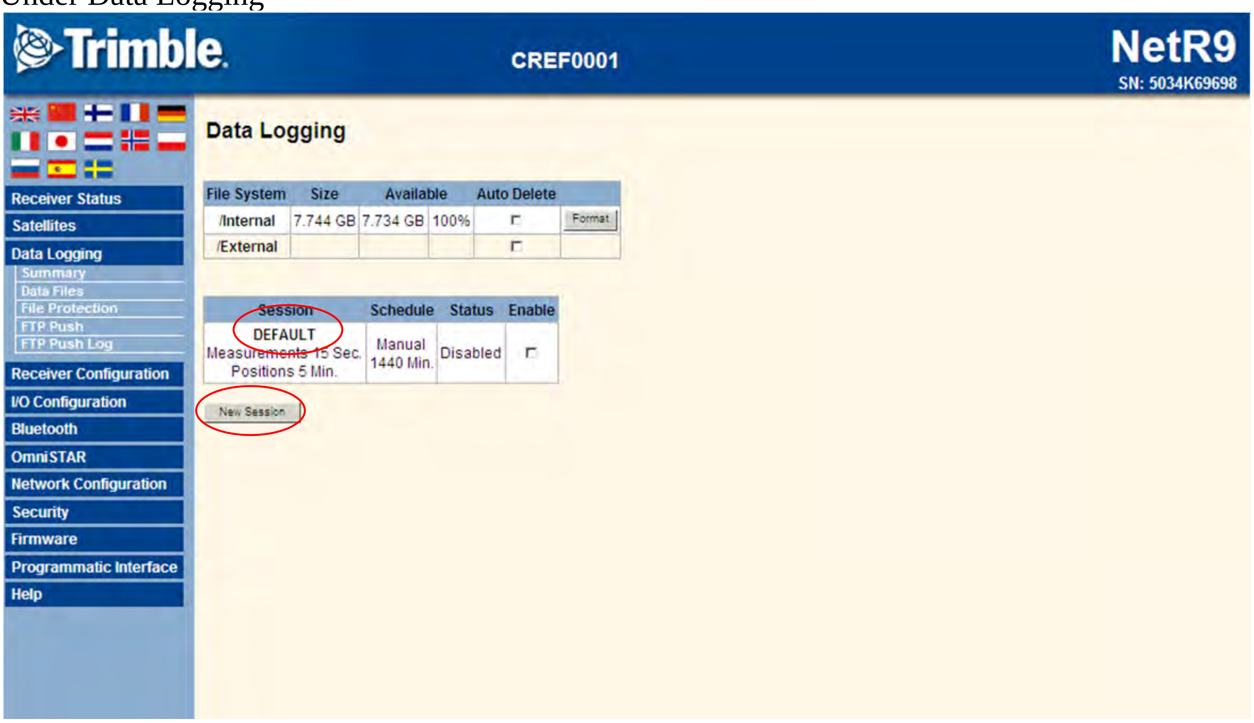
Click disable all, enable all, ok. This gets rid of the check boxes on ignore health.



Keep Defaults

Click disable all, enable all, ok. This gets rid of the check boxes on ignore health. See NOTE made under Tracking section.

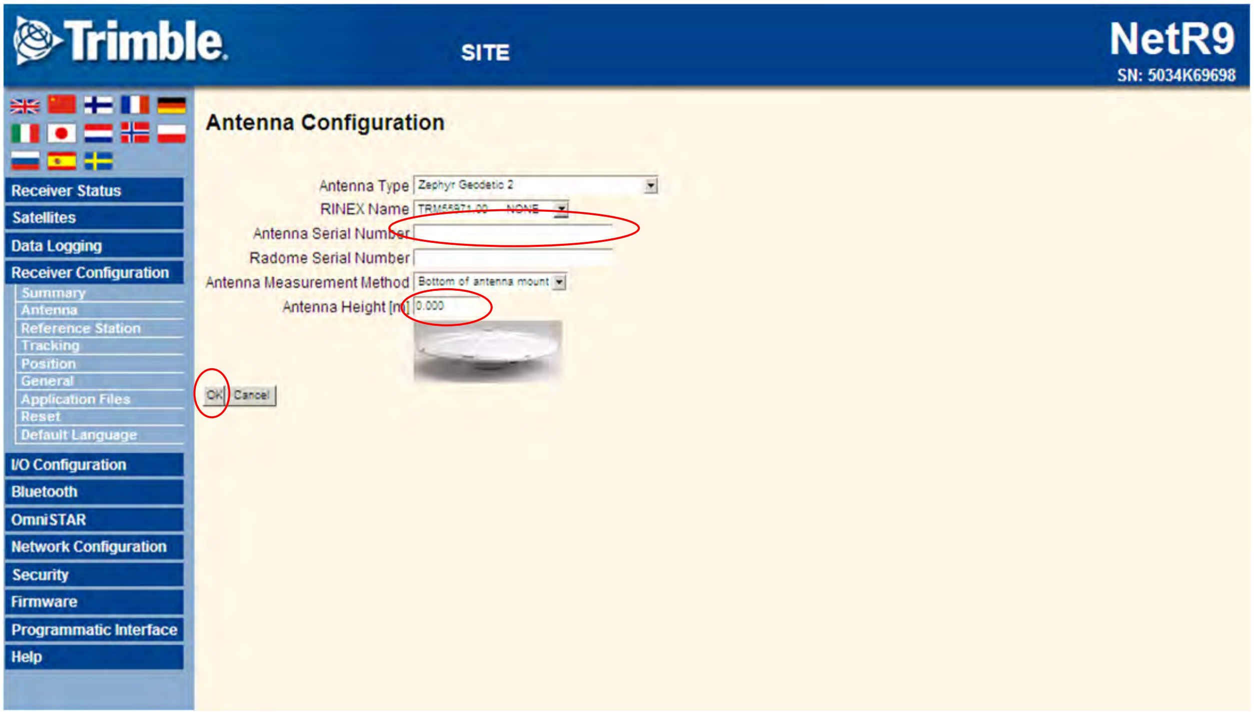
Under Data Logging



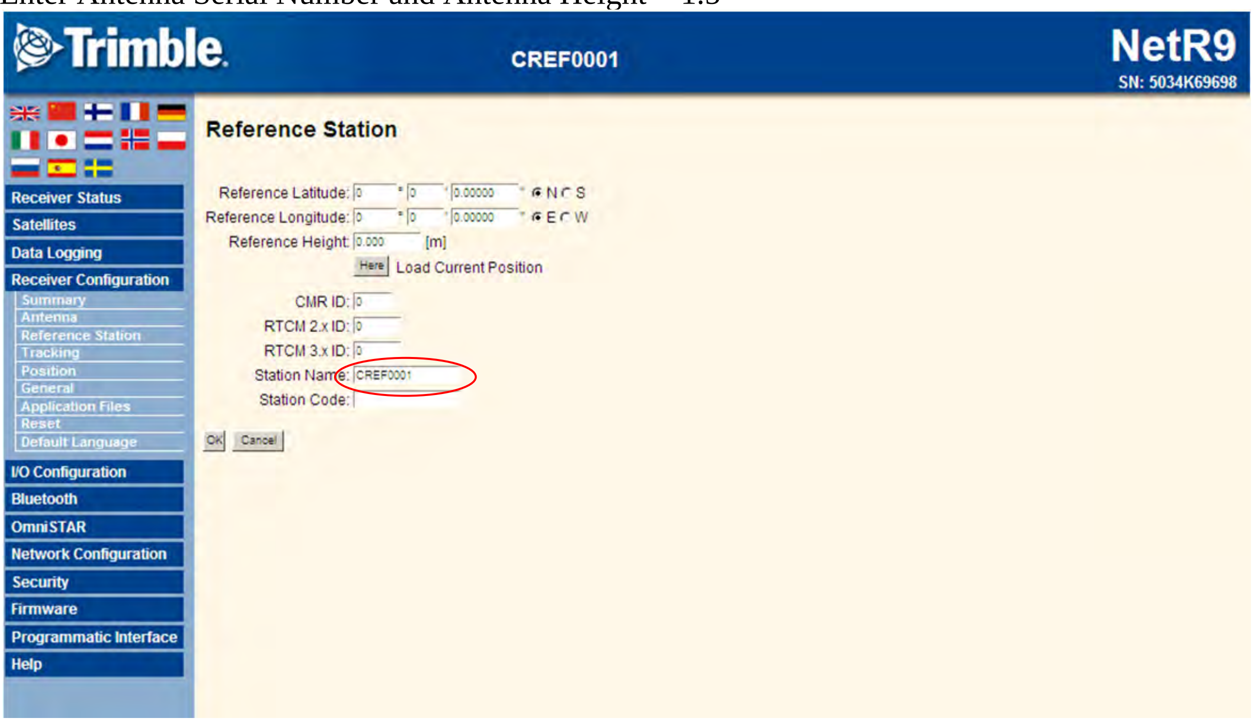
Click on Default; Click enable, set; schedule = continuous, duration = 1440 (this equals 24 hours), Measurement Interval = 1 sec, Position interval = 5 min, Name style = SystJJJh. All other defaults okay. Press Ok

Click New Session and set the following settings; Session name = 30Min, Enable, Schedule = continuous, Duration = 30, Measurement Interval = 1 sec, Position = 5 min, Path Style = Date, Name Style = SystJJJhmm, Press ok.

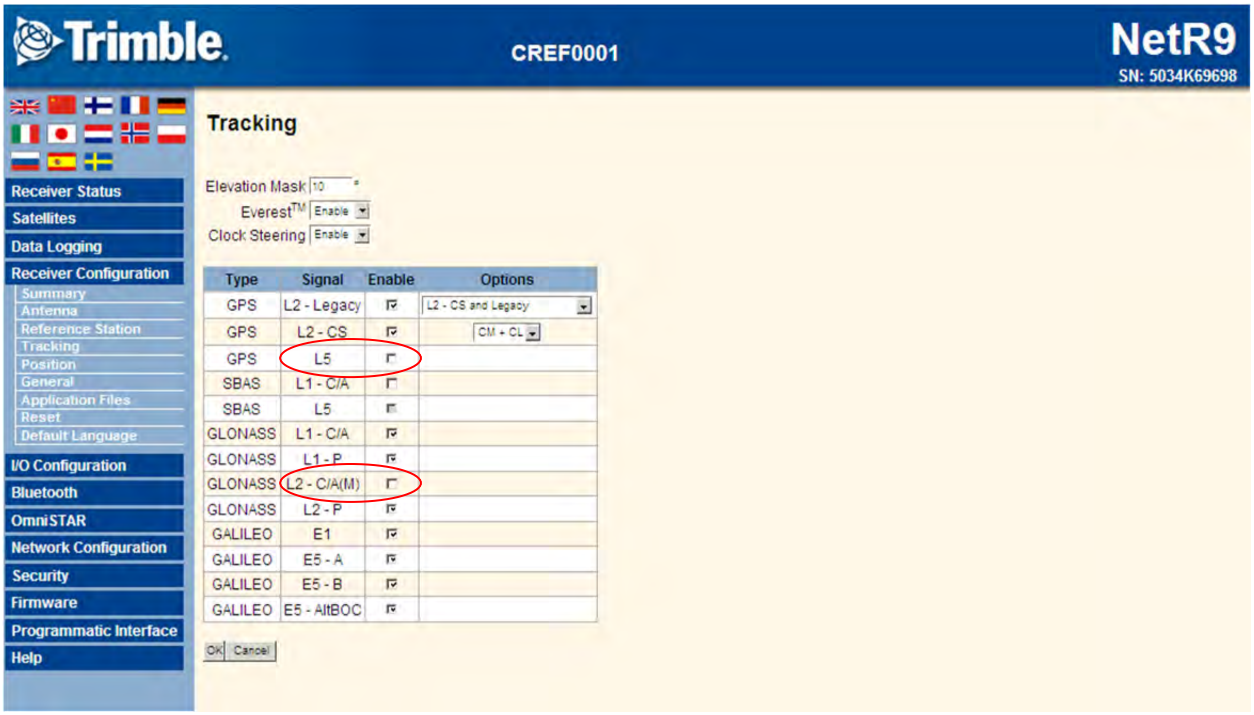
Under Receiver Configuration



Enter Antenna Serial Number and Antenna Height = 1.5



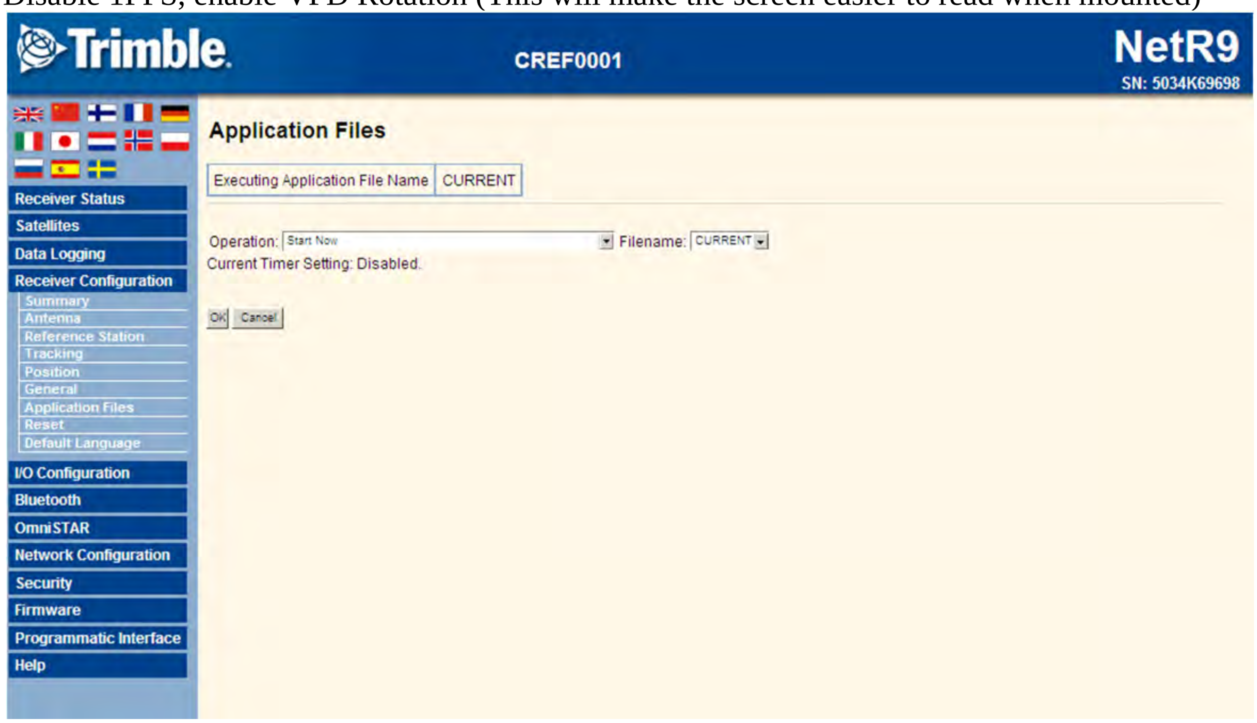
Station Name = Site?



Enable GPS L5 and GLONASS L2. NOTE: enabling the logging of GLONASS and GALILEO will increase the file size. Until more testing is done it is currently not allowed to use these systems for processing. FA will log these systems in addition to GPS L5 for testing purposes for the 2011 season.

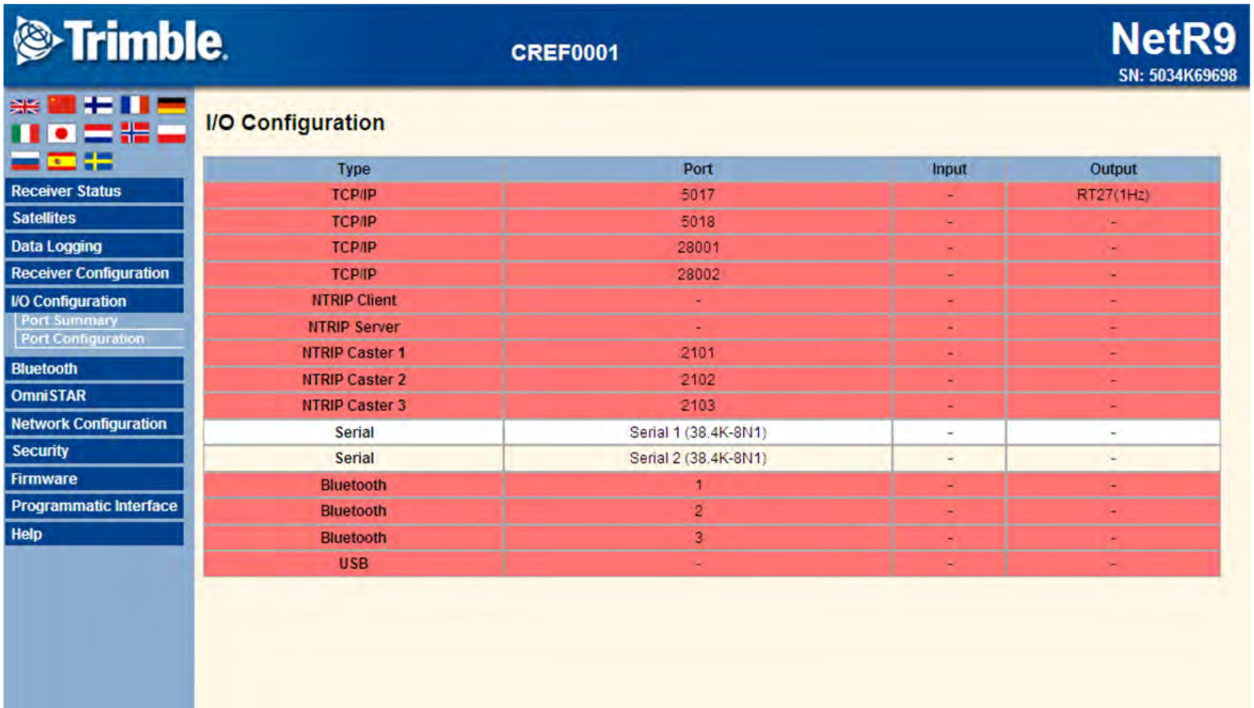
Set PDOP Mask value = 6.

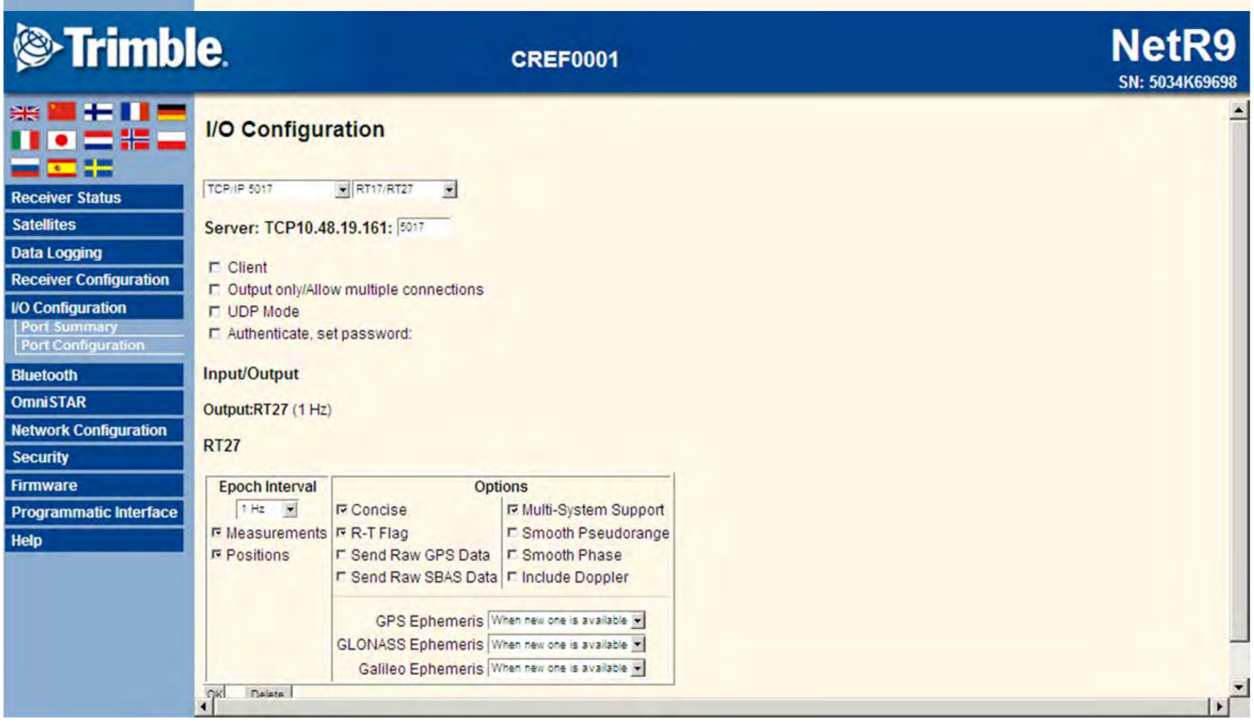
Disable 1PPS, enable VFD Rotation (This will make the screen easier to read when mounted)



Keep defaults

Under I/O Configuration


Trimble
CREF0001
NetR9
SN: 5034K69698
Receiver Status
Satellites
Data Logging
Receiver Configuration
I/O Configuration
Port Summary
Port Configuration
Bluetooth
OmniSTAR
Network Configuration
Security
Firmware
Programmatic Interface
Help
I/O Configuration
Type | Port | Input | Output
TCP/IP | 5017 | - | RT27(1Hz)
TCP/IP | 5018 | - | -
TCP/IP | 28001 | - | -
TCP/IP | 28002 | - | -
NTRIP Client | - | - | -
NTRIP Server | - | - | -
NTRIP Caster 1 | 2101 | - | -
NTRIP Caster 2 | 2102 | - | -
NTRIP Caster 3 | 2103 | - | -
Serial | Serial 1 (38.4K-8N1) | - | -
Serial | Serial 2 (38.4K-8N1) | - | -
Bluetooth | 1 | - | -
Bluetooth | 2 | - | -
Bluetooth | 3 | - | -
USB | - | - | -


Trimble
CREF0001
NetR9
SN: 5034K69698
Receiver Status
Satellites
Data Logging
Receiver Configuration
I/O Configuration
Port Summary
Port Configuration
Bluetooth
OmniSTAR
Network Configuration
Security
Firmware
Programmatic Interface
Help
I/O Configuration
TCP/IP 5017
RT17/RT27
Server: TCP10.48.19.161: 5017
Client
Output only/Allow multiple connections
UDP Mode
Authenticate, set password:
Input/Output
Output:RT27 (1 Hz)
RT27
Epoch Interval
1 Hz
Measurements
Positions
Options
Concise
R-T Flag
Send Raw GPS Data
Send Raw SBAS Data
Multi-System Support
Smooth Pseudorange
Smooth Phase
Include Doppler
GPS Ephemeris
When new one is available
GLONASS Ephemeris
When new one is available
Galileo Ephemeris
When new one is available
OK
Delete

ETHERNET RADIO CONFIGURATION
(to enable remote downloading of basestation data)

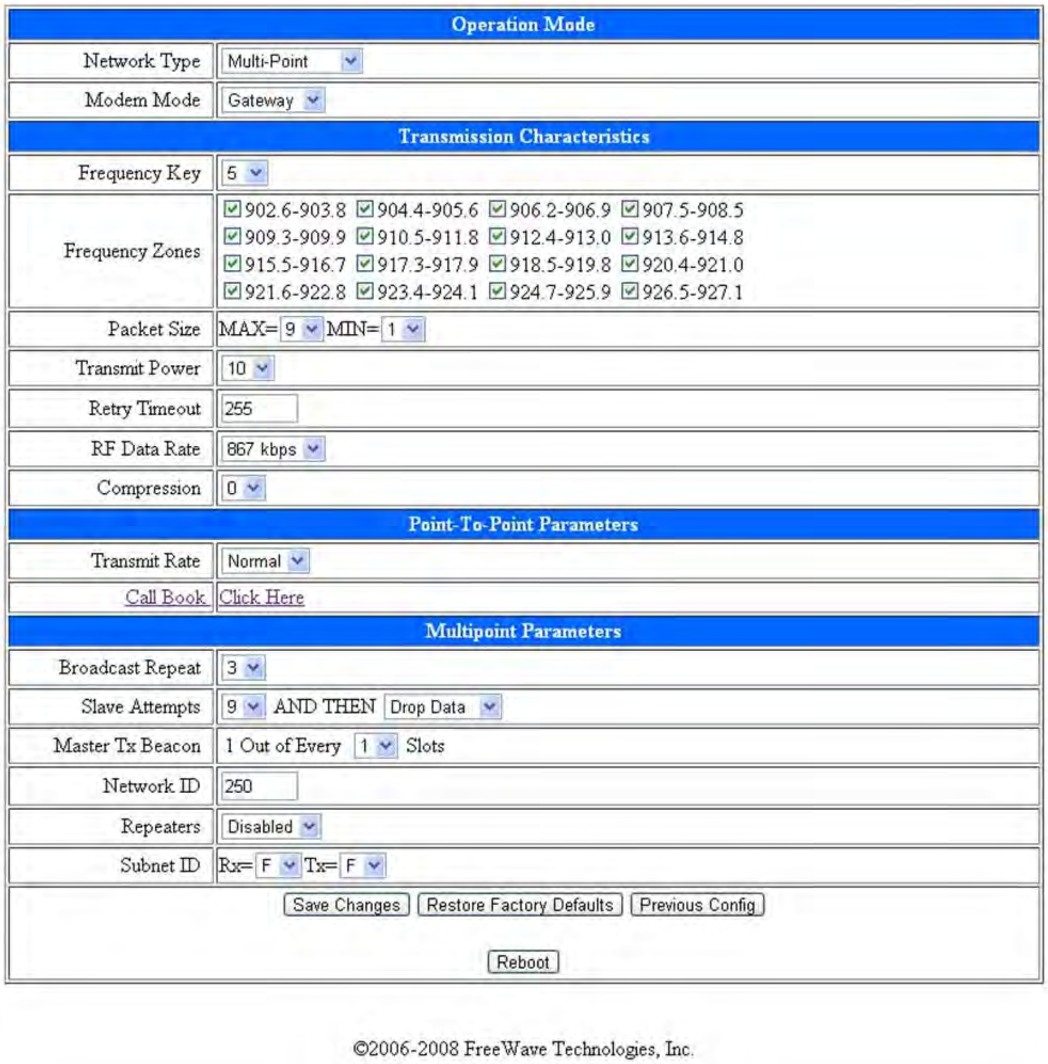
IP Configuration via Serial

This can also be done via the web interface but only if you already know the radio's IP.

1. With the radio off
2. Attach PORT1 on the radio to COM1 on the computer via RS232 9 pin cable
3. Open HyperTerminal and configure the session to connect on COM1
    a. Port Settings: 19200, 8, None, 1, None
4. Power on the radio, in HyperTerminal it will first ask if you want to enter setup, type "y"
5. Next it will prompt you for a password, default password is "admin"
6. Select the IP Setup
7. Configure the station to have the following values
    a. IP Address 10.48.19.### (see IP table)
    b. Subnet Mask 255.255.255.0
    c. Default Gateway 10.48.19.1
    d. Web Port 80
    e. Management VLAN ID 0
    f. Data VLAN ID 0
    g. Tagging N/A
8. After making these changes exit the interface, and reboot the radio

Radio Setup

1. Confirm computer's NIC setup, IP should be in the 10.48.19.XXX subnet.
2. Open IE Browser and navigate to "http://10.48.19.###" (radio's IP)
3. Use the menu on the left side of the page to navigate to "Radio Setup"
4. Under "Operation Mode" configure the following
    a. Network Type: Multi-Point
    b. Modem Mode: Gateway
5. Under "Multipoint Parameters" set the "Network ID" to 250
6. Save changes
7. On radios running firmware version 2.15 you will have to do an explicit reboot as well



Operation Mode	
Network Type	Multi-Point
Modem Mode	Gateway
Transmission Characteristics	
Frequency Key	5
Frequency Zones	☑902.6-903.8 ☑904.4-905.6 ☑906.2-906.9 ☑907.5-908.5 ☑909.3-909.9 ☑910.5-911.8 ☑912.4-913.0 ☑913.6-914.8 ☑915.5-916.7 ☑917.3-917.9 ☑918.5-919.8 ☑920.4-921.0 ☑921.6-922.8 ☑923.4-924.1 ☑924.7-925.9 ☑926.5-927.1
Packet Size	MAX= 9 MIN= 1
Transmit Power	10
Retry Timeout	255
RF Data Rate	867 kbps
Compression	0
Point-To-Point Parameters	
Transmit Rate	Normal
Call Book	Click Here
Multipoint Parameters	
Broadcast Repeat	3
Slave Attempts	9 AND THEN Drop Data
Master Tx Beacon	1 Out of Every 1 Slots
Network ID	250
Repeaters	Disabled
Subnet ID	Rx= F Tx= F
Save Changes / Restore Factory Defaults / Previous Config / Reboot	

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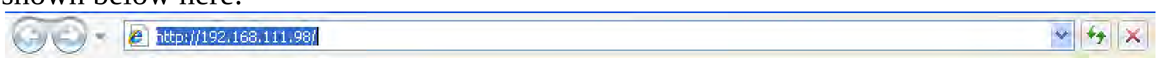
REMOTE DOWNLOAD OF BASE STATION DATA

Connecting to the Ethernet radio

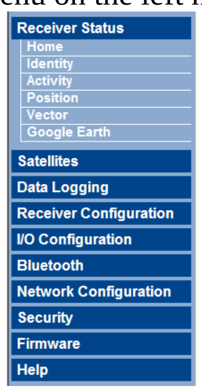
An Ethernet radio is used to communicate with the NetR5. The radio allows for communications with the base station as if it were part of the internet. Make sure the radio is connected to power and has the antenna plugged in. The radios have established a connection if the Carrier Detect (CD) light on the radio is green. Connect the computer to the radio with an Ethernet cable and start a web browser. Radio settings can be checked using the IP address of the radio in a web browser.

Connecting to the basestation

The NetR5/R9 has a web page interface that allows for easy access through a web browser. Communications are established by typing the ip address of the base station into the address bar as shown below here:



The NetR5 website will come up with a menu on the left hand side that looks like:



This menu gives access to all the NetR5 settings and functions.

Start / Stop Logging

Select "Data Logging" the left hand menu:

Data Logging

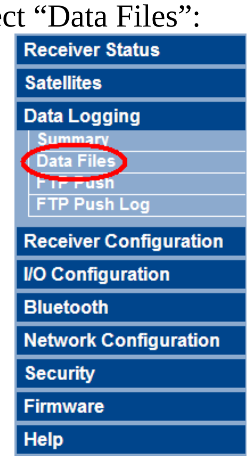
File System	Size	Available		Auto Delete	
/Internal	57.33 MB	53.37 MB	93%	☐	Format
/External				☐	Format

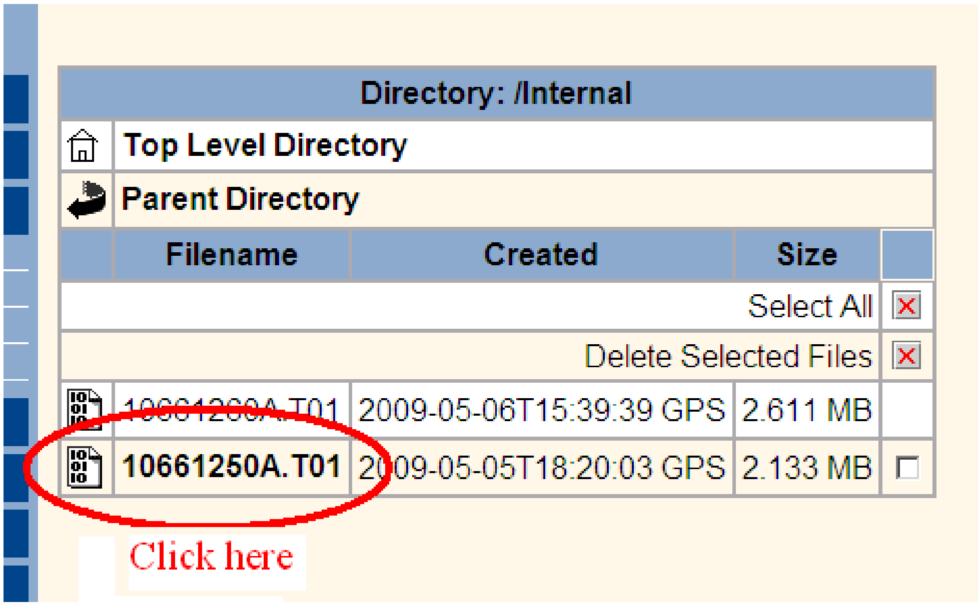
Session	Schedule	Status	Enable
DEFAULT	Always	Disabled	☐
CANOE	Daily 14:00 720 Min.	Logging /Internal/10661260A.T01	☑

By clicking or unclicking the check box next to the station name (CANOE in this case) under the Enable column logging is started or stopped. This session has the correct setting for the base station (elevation mask, logging rate, antenna height, etc) preset.

Downloading Data

Under "Data Logging" on the menu select "Data Files":

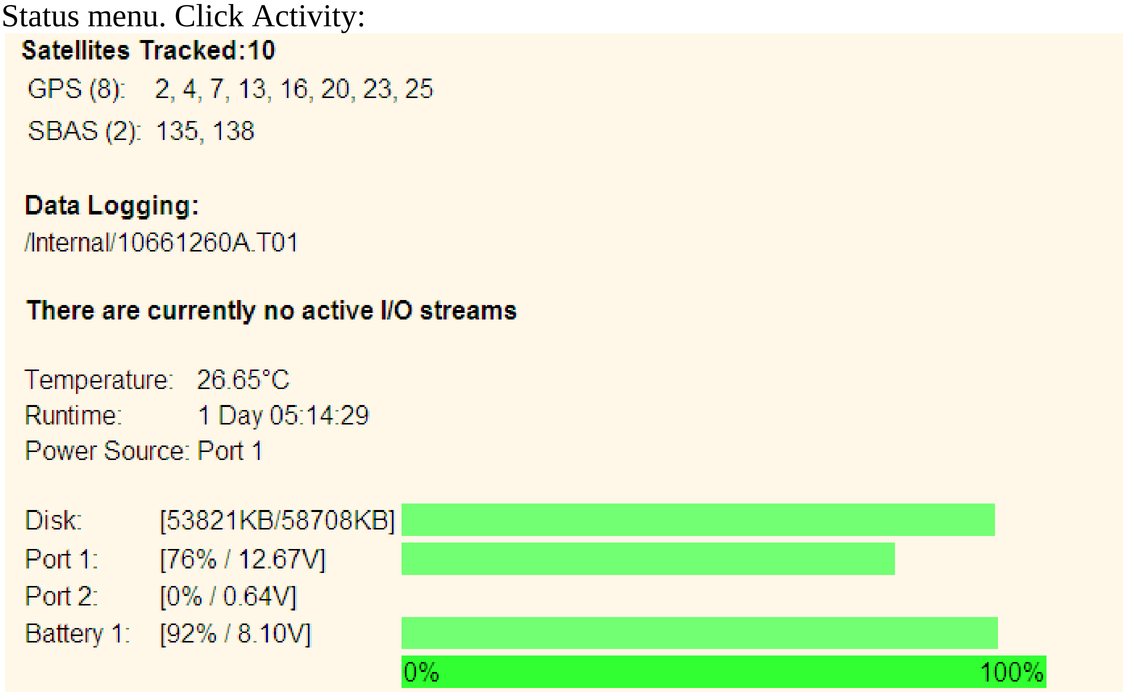




Files that are in bold can be downloaded. The file that is currently being logged cannot be downloaded until logging is stopped. To download data select the desired file. Internet Explorer will object, right click on the bar under the address bar and select "Download file…".

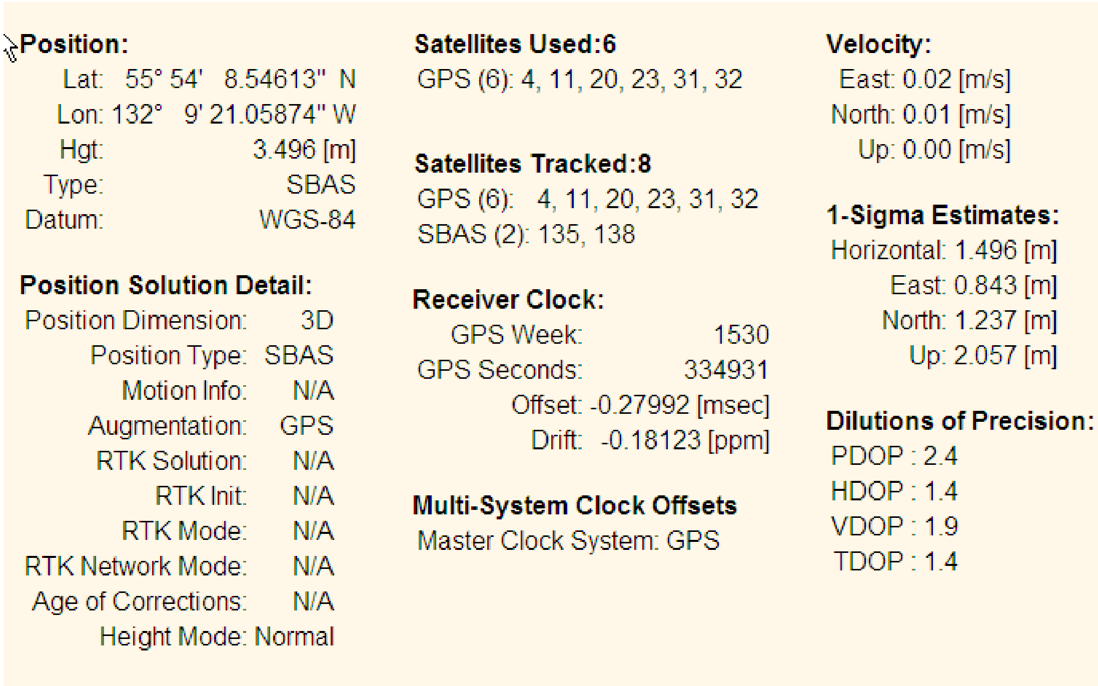
Other things of interest

When logging onto the Base Station there are several attributes to take note of and log. These include the battery level, the amount of memory and PDOP. These can all be found in the Receiver Status menu. Click Activity:



Take note of the Disk numbers (this is the amount left). Log the voltage on Port 1 daily.

Click on the Position Tab:



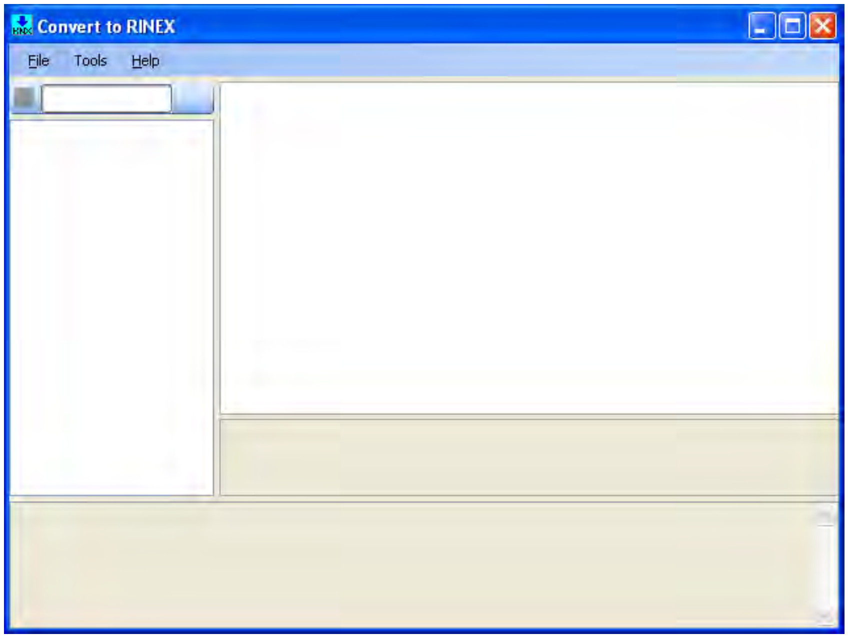
Log the PDOP and number of satellites used when beginning and ending a file.

Information on each Instrument:

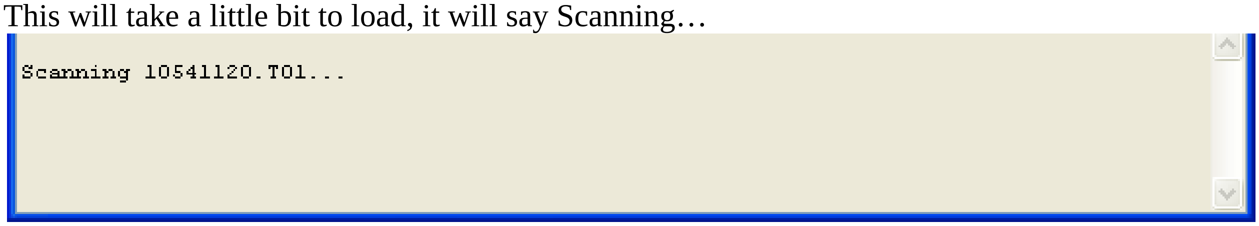
Instrument	IP Address	Corresponding Instrument
Ship Radio	10.48.19.150	Ship’s Network
Shore Radio 1	10.48.19.151	Bert (Trimble 1066)
Shore Radio 2	10.48.19.152	Mobile Radio
Shore Radio 3	10.48.19.153	Ernie (Trimble 1054)
Bert (Trimble 1066)	10.48.19.155	Shore Radio 1
Ernie (Trimble 1054)	10.48.19.156	Shore Radio 3

CONVERTING TO RINEX

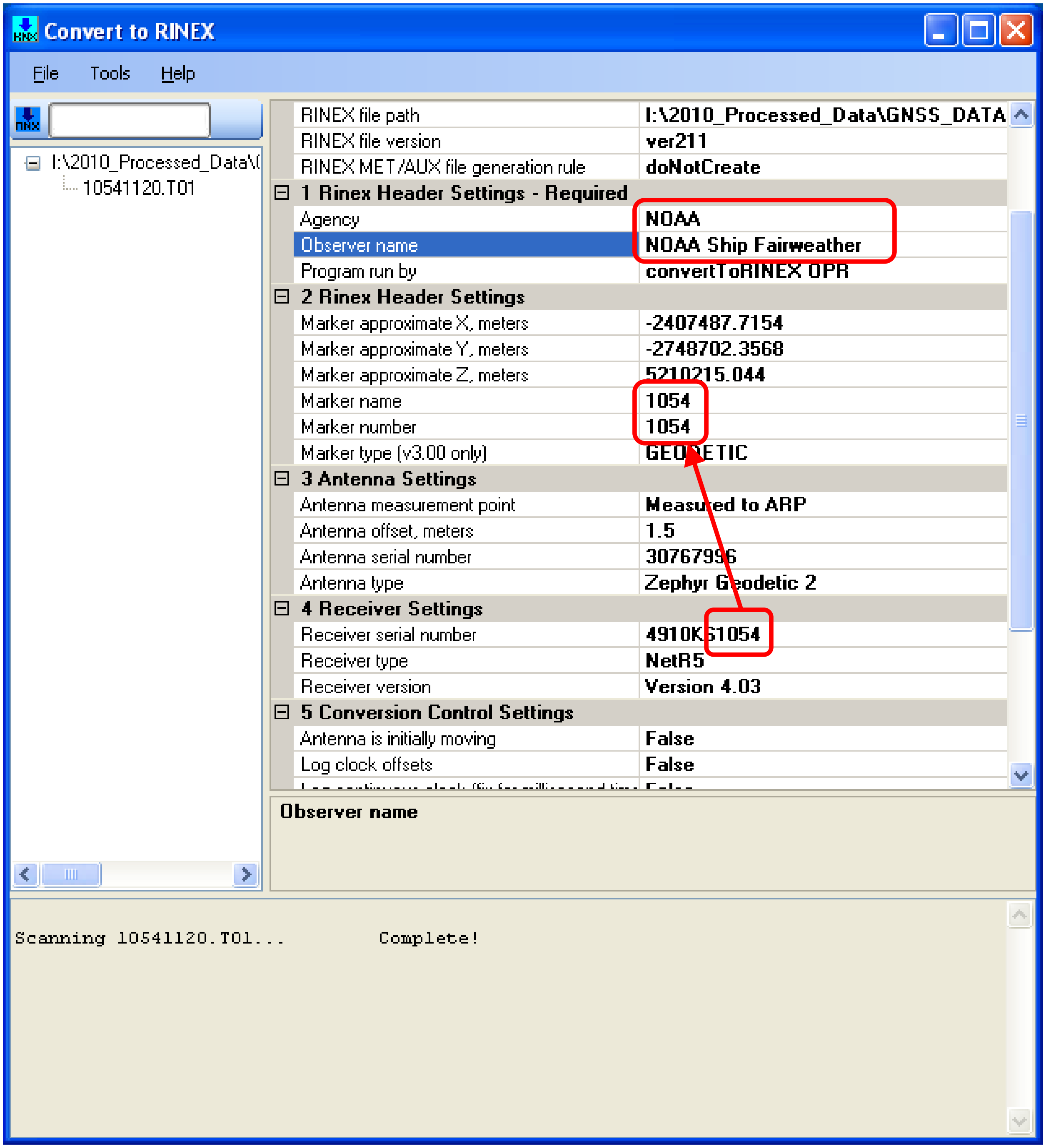
Run *Convert to Rinex* this can be found either on the desktop or on the start menu at *All Programs -> Trimble -> Convert To RINEX*



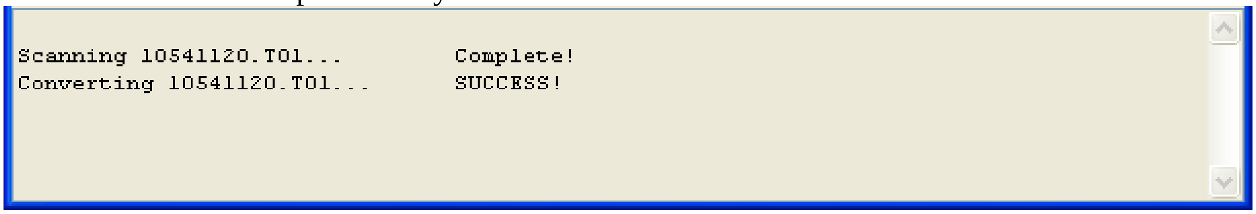
File -> Open to open the .t01 files which are found in *I:\2010_Processed_Data\GNSS_DATA\[*Project_Name*]\Base_Station_Data\[*Base_Name*]*
This will take a little bit to load, it will say Scanning…



Once loaded change the Agency and Observer name to NOAA and NOAA Ship Fairweather (see the image below). Also confirm that the Marker name is the same as the last four of the serial.



Once happy click on *File -> Convert Files*, the status window will say Converting, again this takes a little while and will update to say “*SUCCESS!*” when done.



SUBMITTING TO Online Positioning User Service (OPUS)

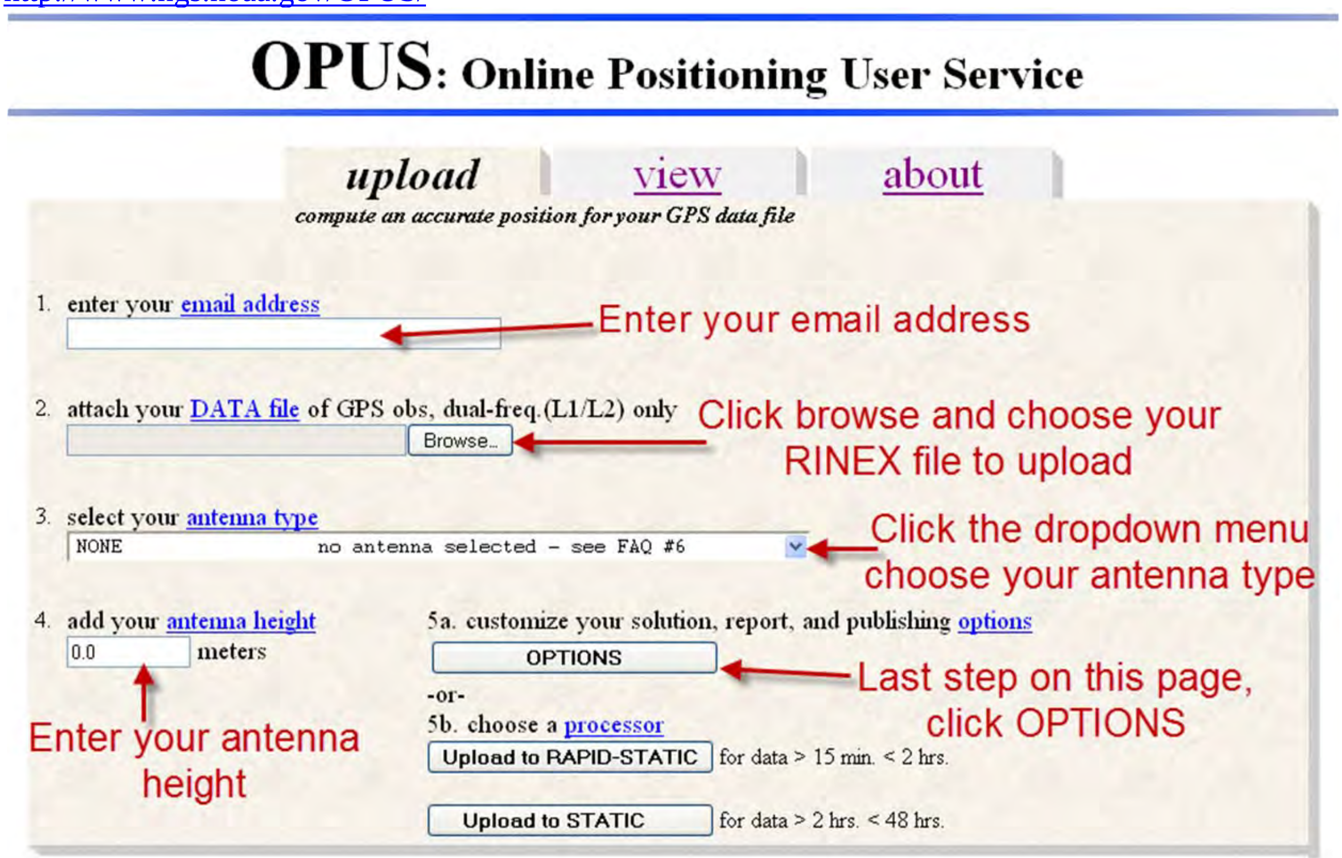
Why Submit?

OPUS is a great tool for getting a very precise position for centimeter accuracy. We use the position calculated by OPUS to correct for inaccuracies in the acquisition platform's position. In addition, Field Procedures say we are required to obtain an OPUS solution from at least a 4 hour observation on a benchmark. We like to submit our base station position to OPUS when we first acquire data and then do a weekly submission in order to verify the position is still accurate during hydrographic acquisition. In order to obtain a precise solution, OPUS can take up to 19 days to obtain a final precise orbit because it uses a combination of seven analysis centers worldwide and these centers take several days to upload the orbit data to the International GNSS Service (IGS).

Obtaining a Solution

After creating a RINEX file from the base station receiver raw file you may then submit the file to OPUS in order to get a precise position solution. If bandwidth is an issue, as it usually is aboard the ship, you may need to decimate and zip the RINEX file in order to get the file size smaller to achieve a reasonable upload time (a 3 mb file usually takes about 3-5 minutes to upload on the ship).

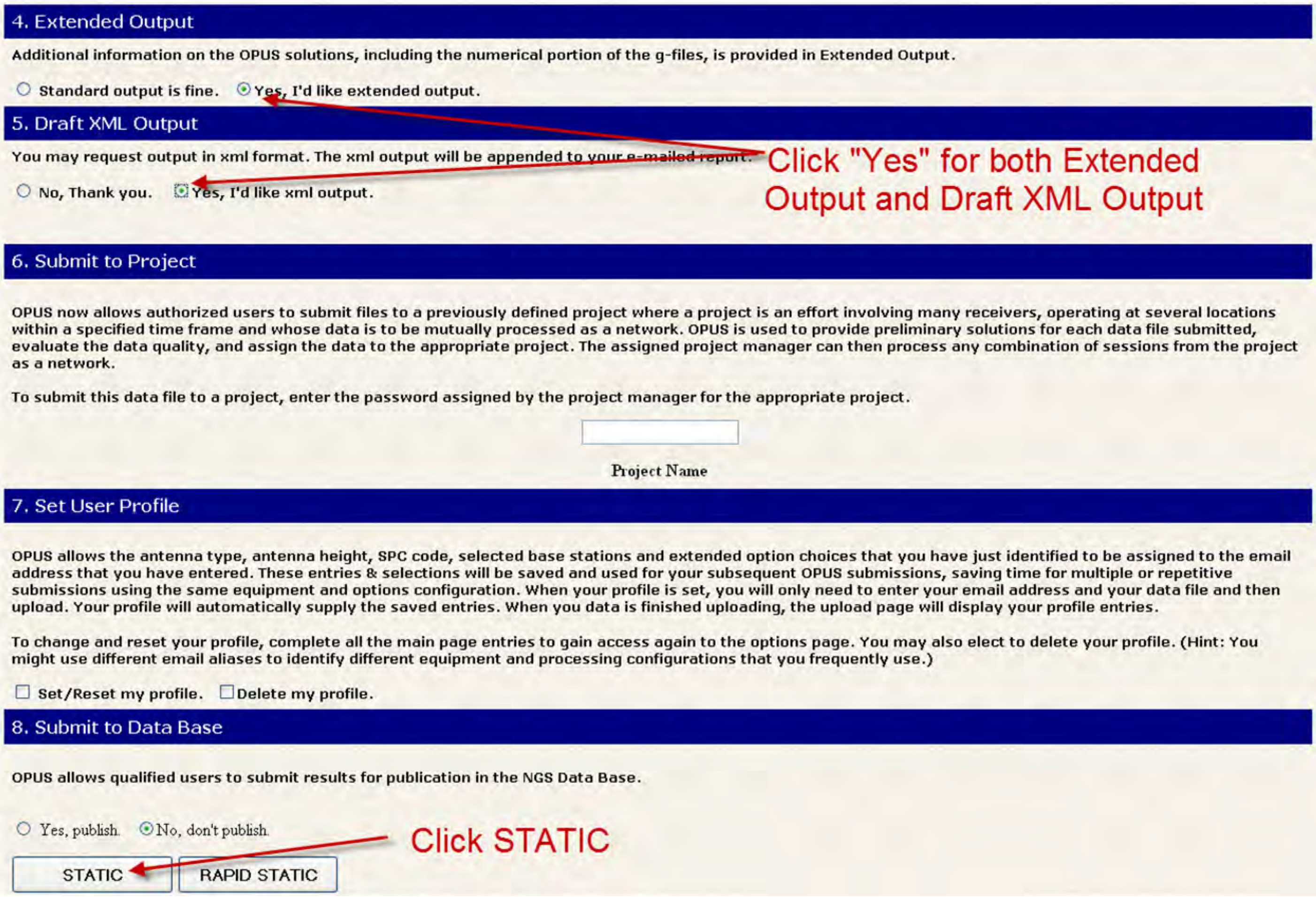
Once your RINEX file size is reasonable, got to the OPUS website at:
http://www.ngs.noaa.gov/OPUS/



From the figure above follow these steps:

1. Enter your email address
2. Browse and select your RINEX file, this is your .10O file

3. Select your antenna type from the dropdown, for FA this will either be the Trimble antenna (TRM55971.00 Zephyr GNSS Geodetic Model 2) or the Ashtech antenna (ASH701975.01AGP Geodetic IV, Rev. A with groundplane)
4. Enter your antenna height. This will usually be 1.5 meters, which is what you set your tripod height to.
5. Click the OPTIONS button. This will take you to the following page



Leave all numbered sections as is except for 4. Extended Output and 5. Draft XML Output. Choose "Yes" for both of these and they will be included in the OPUS solution emailed to you. At the bottom section 8. Choose "STATIC" if your observation was more than 2 hours. This will give you a more precise solution.

After choosing "STATIC" you should receive a pop-up window stating that your file is being uploaded. Once it is uploaded, it will take some time for OPUS to create a solution. Check your email in about 15 minutes and you should receive a solution. Once you do, open the email and save all the text as your OPUS solution. The solution will give you useful information like your antenna name, antenna height, start and stop times of the observation, and most importantly, your latitude, longitude, and ellipsoid height (this position is what you will input for your base station coordinates in POSPAC when processing true heave data).

```
From    opus <opus@NGS.noaa.gov>
Sent   Wednesday, July 21, 2010 3:59 pm
To  Albert.Davison@noaa.gov
Subject  OPUS solution : 1054200_concat_dec.10o 000046305
Attachments  1054199v.10o.xml 13K

 FILE: 1054200_concat_dec.10o 000046305
```

observation start and stop time

antenna type and height

```
                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

      USER: albert.davison@noaa.gov                    DATE: July 21, 2010
RINEX FILE: 1054199v.10o                               TIME: 23:59:27 UTC


  SOFTWARE: page5  0909.08 master2.pl 0810233      START: 2010/07/18  21:44:00
 EPHEMERIS: igr15930.eph [rapid]                    STOP: 2010/07/19  23:59:00
  NAV FILE: brdc1990.10n                        OBS USED: 7770 / 7876   :  98%
  ANT NAME: TRM55971.00        NONE            # FIXED AMB:   296 /   301   :  98%
ARP HEIGHT: 1.3                                OVERALL RMS: 0.011(m)
```

lattitude, longitude, and ellipsoidal height

```
 REF FRAME: NAD_83(CORS96)(EPOCH:2003.0000)            ITRF00 (EPOCH:2010.5465)

        X:      -2606610.795(m)   0.008(m)        -2606611.776(m)   0.008(m)
        Y:       -609104.779(m)   0.005(m)         -609103.754(m)   0.005(m)
        Z:       5769830.520(m)   0.014(m)         5769830.949(m)   0.014(m)

      LAT:   65 15 29.96293       0.003(m)       65 15 29.94755     0.003(m)
    E LON:  193  9  9.68554       0.005(m)      193  9  9.59143     0.005(m)
    W LON:  166 50 50.31446       0.005(m)      166 50 50.40857     0.005(m)
   EL HGT:            8.233(m)    0.016(m)                8.925(m)  0.016(m)
 ORTHO HGT:           4.404(m)    0.016(m) [NAVD88 (Computed using GEOID09)]

                         UTM COORDINATES     STATE PLANE COORDINATES
                          UTM (Zone 03)         SPC (5008 AK 8)
Northing (Y) [meters]      7238507.767          1254365.086
Easting (X)  [meters]       413738.910           460419.043
Convergence  [degrees]     -1.67783609          -0.76953979
Point Scale                 0.99969110           0.99991917
Combined Factor             0.99968981           0.99991789
```

associated RMS values

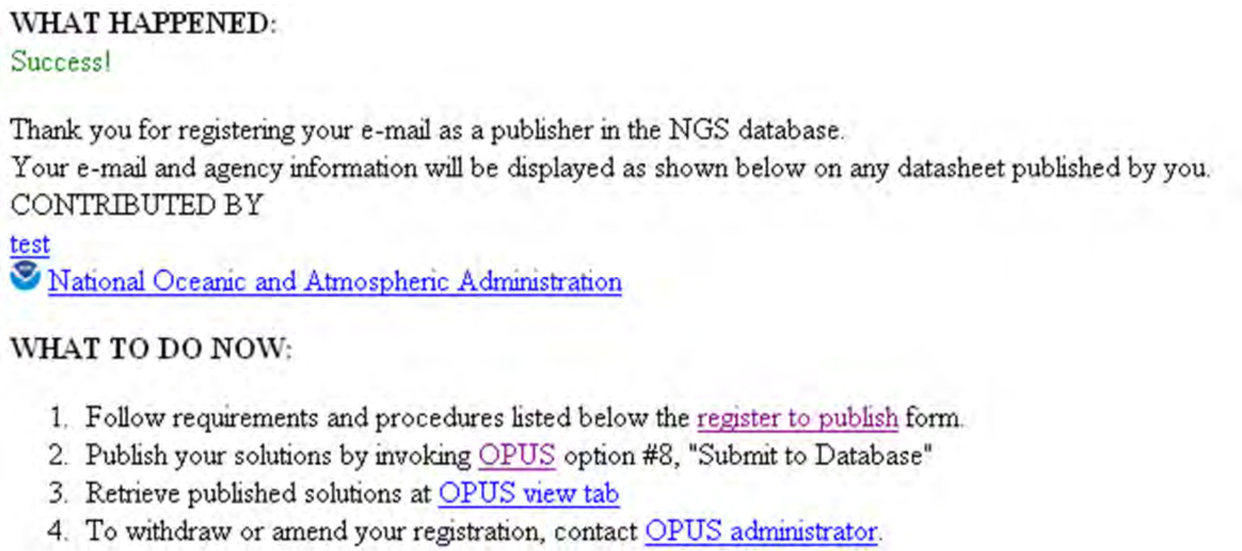
```
US NATIONAL GRID DESIGNATOR:  3WVN1373838507(NAD 83)


                          BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DL6423 AB11 NOME_ANVILAK2006 CORS ARP     N643352.198 W1652224.356  104162.6
DL6675 AB18 KOTZEBUE__AK2007 CORS ARP     N665130.119 W1623648.521  261834.1
DL6684 AC07 BUCKLAND__AK2007 CORS ARP     N655740.665 W1611711.714  267931.5

                 NEAREST NGS PUBLISHED CONTROL POINT
UW4186      CON PT SPENCER CONT TWR 1950    N651545.450 W1665104.374     512.3
```

Submitting to the OPUS Database

You first must register with OPUS in order to submit to their database. To register go to their main page: http://www.ngs.noaa.gov/OPUS/ and click on their "View" tab

Scroll down the page and complete the following steps:

1. Select your agency from the dropdown menu, this should be National Oceanic and Atmospheric Administration
2. Enter your email address
3. Read the "Terms of use" and check the accept terms button
4. Once complete, click the "Register" button


WHAT HAPPENED:

Success!

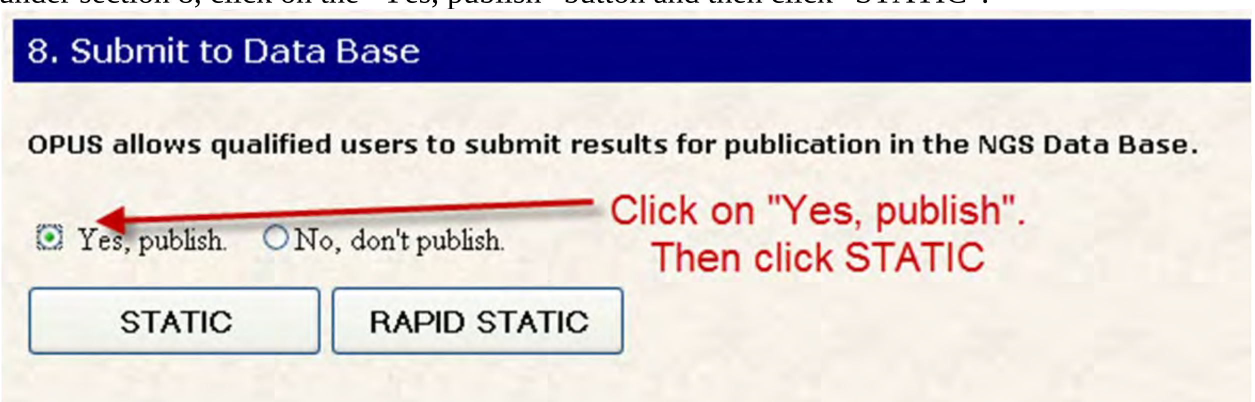
Thank you for registering your e-mail as a publisher in the NGS database.
Your e-mail and agency information will be displayed as shown below on any datasheet published by you.
CONTRIBUTED BY
test
National Oceanic and Atmospheric Administration

WHAT TO DO NOW:

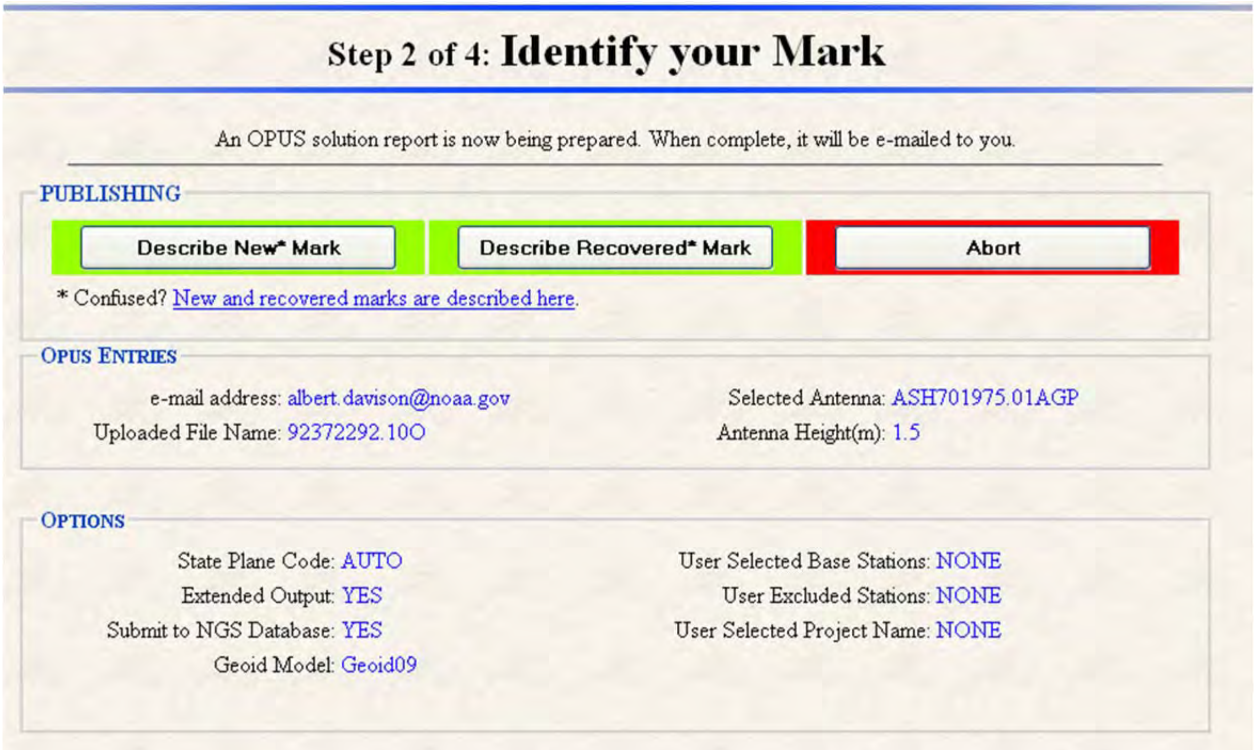
1. Follow requirements and procedures listed below the register to publish form.
2. Publish your solutions by invoking OPUS option #8, "Submit to Database"
3. Retrieve published solutions at OPUS view tab
4. To withdraw or amend your registration, contact OPUS administrator.

If your registration was successful, you should see the information above and you are now registered with OPUS DB.

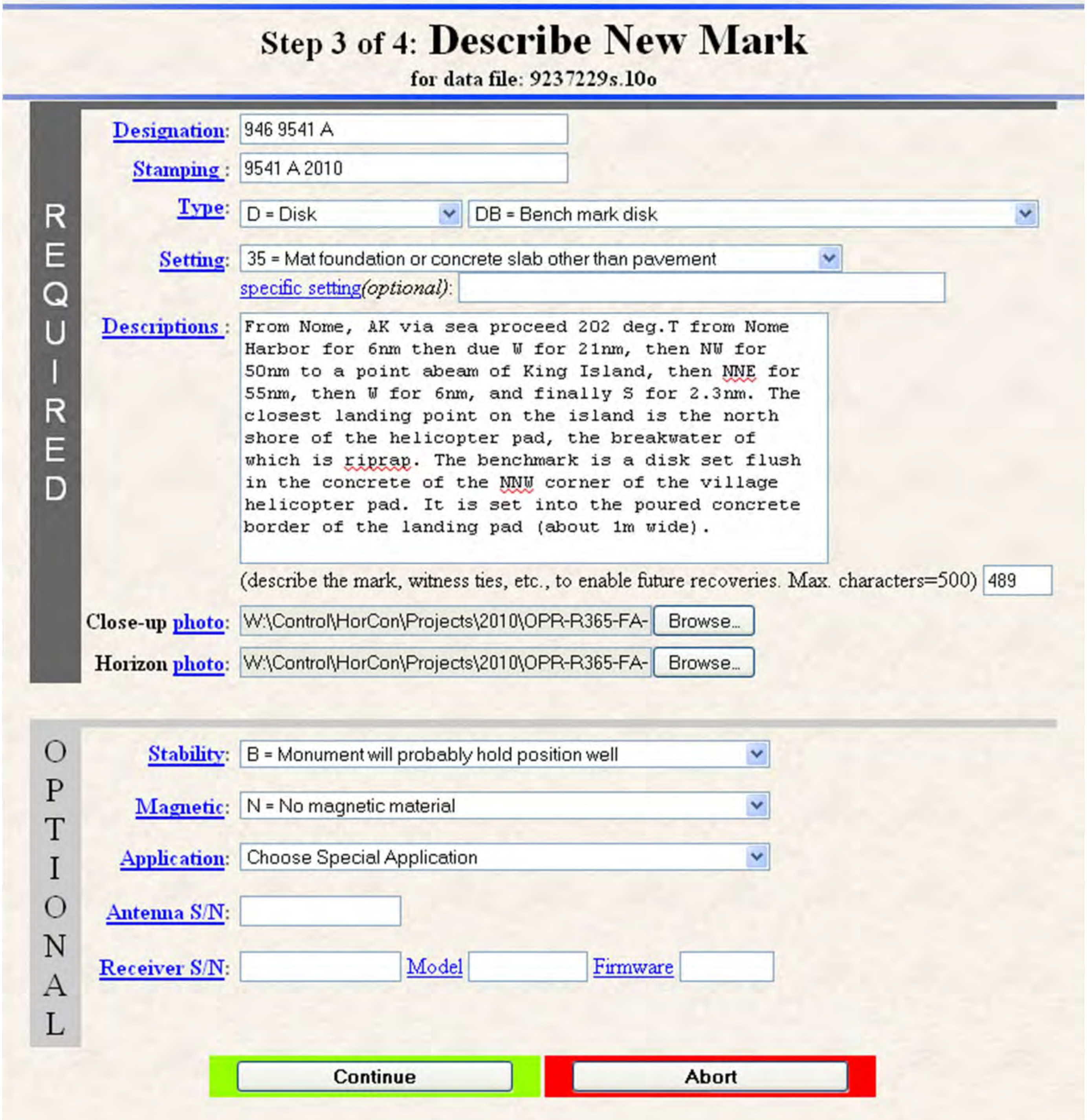
Now you are ready to submit. Go through the same process as above for obtaining a solution with the email you used to register with OPUS DB. The only difference is that on the OPTIONS page, under section 8, click on the "Yes, publish" button and then click "STATIC".



After your RINEX file finishes uploading, you should get the step 2 of 4 page, "Identify your Mark".



From the page above, double check your OPUS entries and click on one of the publishing options, New Mark, Recovered Mark, or Abort. In most cases you will be describing a new mark so you can click the button marked, “Describe New Mark”. If any of your OPUS entry information is incorrect, you can click the “Abort” button and start over. Once you click on “Describe New Mark” you should get the page below, “Step 3 of 4: Describe New Mark”.



Make sure to fill in all required fields:

- Designation: This is a user-friendly identifier, unique for the area and usually descriptive of the mark stamping and/or location. For tidal benchmarks, you can find the designation under the tides COOPS submission under “Bench Mark Descriptions” in the W drive.
- Stamping: Is the unique lettering, if any, manually added to the mark by the original marksetter. For tidal benchmarks, you can find this in the “Bench Mark Descriptions”.

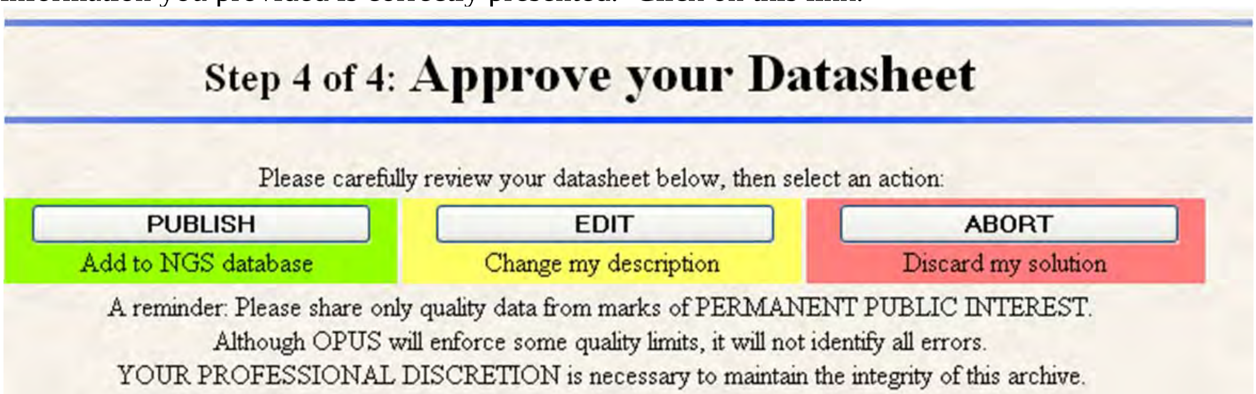
- Type: This describes the surveyed object. For our purposed, the most likely type is a "D=Disk". When you choose disk, you will then be given a dropdown to the right of "Type" which you need to identify the type of disk. In most cases this will be "DB=Bench mark disk".
- Setting: This is the structure to which the mark is affixed. This can sometimes be found in the "Bench Mark Descriptions" described above. The most common will be:
  - 2 = Object driven into ground
  - 66 = In rock outcrop or ledge
  - 80 = In a boulder
- Descriptions: Describe new marks by noting distances and directions to local witnesses (posts, trees, curbs, etc.) along with any other salient features (recommended approach, hazards, etc.). This will help future surveyors recover and assess the suitability of your mark. In most cases you can find a suitable description in the "Bench Mark Descriptions" described above.
- Close-up photo: Use the browse button to select a close up photo of the mark

- Horizon photo: Use the browse button to select a horizon photo of the mark

For optional fields, make sure to fill in at least stability and magnetic:

- Stability: This is your best estimate of the mark's ability to maintain a long-term, constant position relative to other local features. Consider the setting quality, soil type, threats from construction or traffic, etc.
- Magnetic: Copper, brass, aluminum, and stainless steel are not magnetic. Alloys containing iron, cobalt or nickel are magnetic. Use a magnet to test. Most of the marks we recover are not magnetic.

Once this is complete, click on the “Continue” button.
You should then see a page which states, “Almost Done…”. At this point check for an email from OPUS. In the body of the email, you should be prompted to click on a link to verifty that the information you provided is correctly presented. Click on this link.



You should be sent to the “Step 4 of 4: Approve your Datasheet” page. From this page, you can either publish, edit, or abort your submission. If you feel your submission is complete and correct, click on the “PUBLISH” button.
OPUS will then review your submission and if accepted, will publish the database submission on their website. You can check to see if your submission has been published by click on the “View” tab from the OPUS main page. You can then click on one of the many ways you can retrieve datasheets. The most common would be by “email of submitter”. Once it is published it should look similar to the following:

SURVEY DATASHEET (Version 1.0)

PID: BBCC45
Designation: 946 9541 A
Stamping: 9541 A 2010
Stability: Monument will probably hold position well
Setting: Mat foundation or concrete slab other than pavement
Description: From Nome, AK via sea proceed 202 deg.T from Nome Harbor for 6nm then due W for 21nm, then NW for 50nm to a point abeam of King Island, then NNE for 55nm, then W for 6nm, and finally S for 2.3nm. The closest landing point on the island is the north shore of the helicopter pad, the breakwater of which is riprap. The benchmark is a disk set flush in the concrete of the NNW corner of the village helicopter pad. It is set into the poured concrete border of the landing pad (about 1m wide).
Observed: 2010-07-27T22:28:00Z
Source: OPUS - page5 1009.28

Close-up View

REF_FRAME:	EPOCH:	SOURCE:	UNITS:	SET PROFILE	DETAILS
NAD_83(CORS96)	2003.0000	NAVD88 (Computed using GEOID09)	m		

LAT:	65° 45' 30.51839"	± 0.018 m
LON:	-168° 57' 13.22546"	± 0.013 m
ELL HT:	8.718	± 0.034 m
X:	-2577428.090	± 0.005 m
Y:	-503164.318	± 0.013 m
Z:	5792949.800	± 0.039 m
ORTHO HT:	6.618	± 0.058 m

	UTM 2	SPC 5009(AK 9)
NORTHING:	7294516.249m	1310260.245m
EASTING:	593740.030m	547950.469m
CONVERGENCE:	1.86602113°	0.95408208°
POINT SCALE:	0.99970757	0.99992814
COMBINED FACTOR:	0.99970620	0.99992677

CONTRIBUTED BY

albert.davison
National Oceanic and Atmospheric Administration

Horizon View

Congratulations, you have now successfully submitted a mark to the OPUS database for all to see.

USING POSPAC MMS TO COMPUTE VESSEL OFFSETS

Computing Vessel Offsets with POSPac
(Calibrated Installation Parameters)

For 2011 testing we are post-processing the POSMV files recorded during the GAMS calibration to refine offsets between the IMU reference point and the primary antenna phase center. The GAMS calibration data is used because in general it is the most dynamics that a vessel will see. This helps resolve the offsets quickly in post processing and to a higher degree of confidence.

Reference Station

All of the GAMS calibrations were run in the North end of Lake Washington in the vicinity of the NOAA Sand Point facility. Because of the proximity to the CORS station SEAI <http://www.ngs.noaa.gov/cgi-cors/corsage.prl?site=SEAI> SingleBase is deemed the most appropriate processing method.

POSPac does not download the full data rate of station SEAI (1 sec). It will need to be manually downloaded. To get a trimmed file (save bandwidth) use the User Friendly CORS website <http://www.ngs.noaa.gov/UFCORS/>. While the site requests that 1 second data requests be limited to 2 hours there is no restriction if additional is needed. Grab only what you need but don't hesitate to grab extra, it's all in the family.

File Management

All the POSMV files from the GAMS calibration will be stored by vessel in:

T:\Testing_2010\GNSS\POSMV Files\GAMS_Calibrations

or

\\Survey-server\Survey_3\Testing_2010\GNSS\POSMV Files\GAMS_Calibrations

A folder has been created on the W drive for the POSPac projects and base station data, again by vessel:

W:\Control\HorCon\Testing_2010

or

\\Survey-server\Hydro_1 (H)\Control\HorCon\Testing_2010

Processing

The general idea is to process the POSMV data multiple times at the 10cm confidence level. Each time inputting the resulting calibrated installation parameters as the initial lever arm offsets for the following run. This is repeated until the resulting offsets vary by only millimeters.

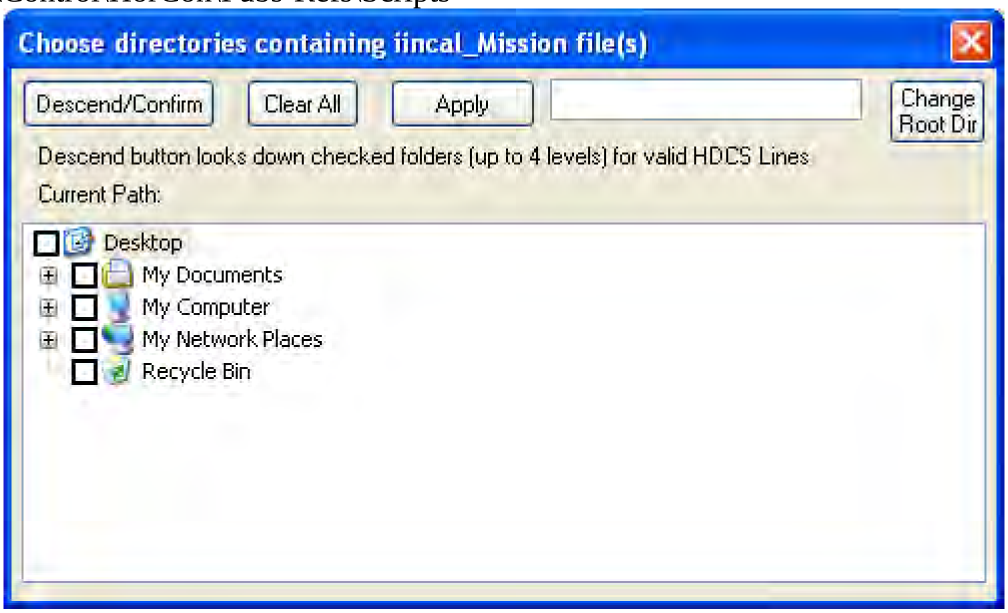
To process drag, both files (Rinex and POSMV) into POSPac. You will not need to enter coordinates for SEAI because the NAD83 coordinates are in the Rinex header and it really doesn't matter because as with ERDDM we are concerned with relative differences not absolute.

Make sure to select the base station and in the right click dialog click “Set Base Station.” For the first run you will also want to confirm the lever arm offsets in the Project Settings -> GNSS-Inertial Processor -> Lever Arms and Mounting Angles. The “Reference to IMU Lever Arm” should not be changed but should be checked; X:-0.008, Y:-0.031, Z:0.130 (unless processing S220 which does not reference the mark on the IMU).

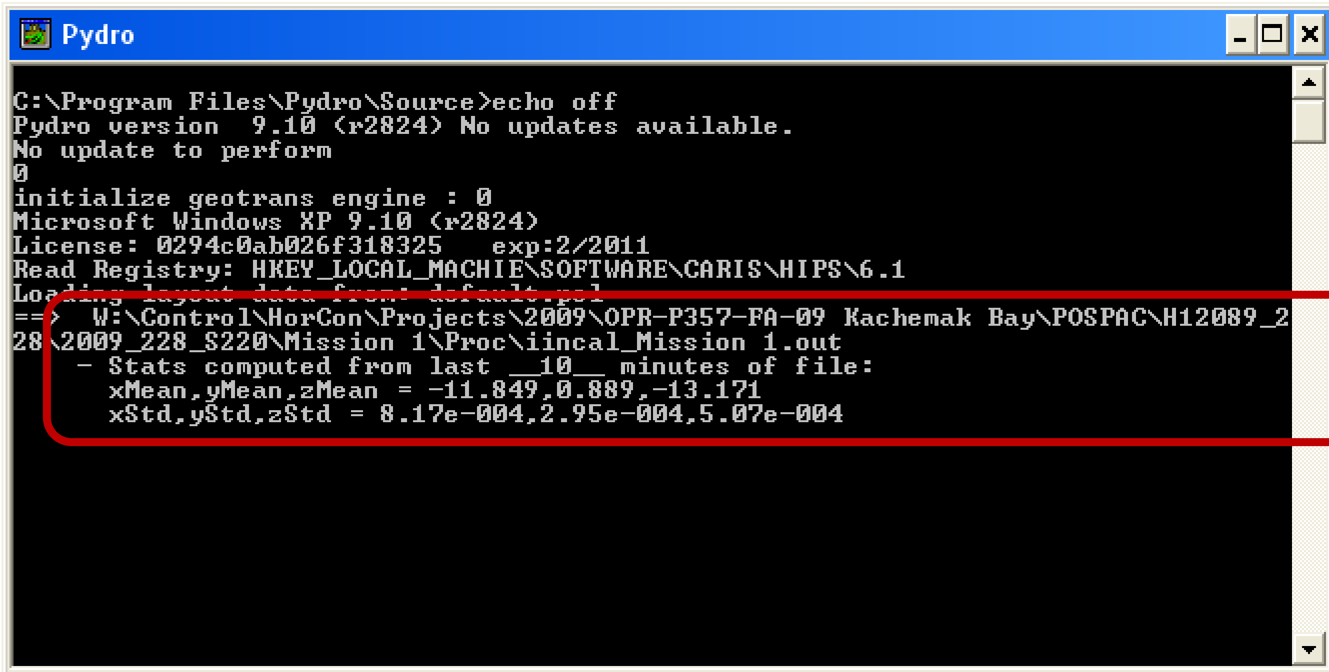
Run backward, forward and combine. After the first run do a basic QC check, make sure there aren’t gaps in data, low numbers of satellites, or terrible DOP in the solution, review RMS… get confident in the dataset.

To get statistically robust final values for the calibrated installation parameters there is a handy macro that runs in Pydro. Open Pydro, on the menu bar select Misc -> Run Macro. The Macro is located in:

W:\Control\HorCon\Pubs-Refs\Scripts



Navigate to and check the project name, click descend/confirm, this will find the “Proc” folder. Then click Apply, it will look like nothing happened. In the background behind the Pydro window is the command prompt associated with Pydro the macro will have output the data in this window.



Note the values and standard deviations, rinse and repeat. Input these new values to the lever arm.

Example offset processing for vessel 2805

	X	Y	Z
Start	-0.806	-0.682	-3.623

Trailing 10 minute average

	X	X Std	Y	Y Std	Z	Z Std
Run 1	-0.787	0.000689	-0.73	0.000215	-3.153	0.000758
Run 2	-0.788	0.000692	-0.73	0.000198	-3.138	0.0013
Run 3	-0.788	0.000692	-0.73	0.000197	-3.137	0.00133

ELLIPSOIDALLY REFERENCED DYNAMIC DRAFT MODEL (ERDDM)

Analysis Using the Pydro macro ProcSBETDynamicDraft

Step One: Establish desired tide package in Pydro: (a) Discrete Zoned Tides or (b) TCARI

1 (a) If you have Discrete Zoned Tides (ZDF + .TID(s))

From Pydro's main menu, ***Tides > Load Zoning Data*** (.ZDF)

Tides > CO-OPS Office Tools > Download Zoned Tide Stations
- Pydro console window will echo a "trying to download stations" list
- If you have problems, or you don't otherwise have internet access, you can consult with HSD and your HSTP representative to obtain a stations file for your ERDDM analysis. Such a station file is loaded "manually" via ***Tides > CO-OPS Office Tools > Load Zoned Tide Stations***

<OR>

1 (b) If you have TCARI Tides

From Pydro's main menu, ***Tides > Load TCARI Data*** (.tc)

Step Two: (a) Examine discrete or TCARI zones and (b) load/view water levels

2 (a) To see the ZDF or TCARI zones in a Chart Window

Window > Show/Hide > Display Properties (or F3 key if Pydro window frame has focus)
- Plotting tab: Check "Tides" in Auto Draw & Middle Button Mouse Draw
- Press the Zoom to Chart Overview (Globe toolbar button) on Chart Window, then Middle Button on mouse to refresh the display--drawing zones

<AND>

2 (b) To load water level data for both discrete and TCARI zones in a Chart Window

Tides > Load WL Data or ***Tides > Download WL Data***, for the applicable to ERDDM data acquisition
- QC WL data via ***Tides > Show WL Graphs***

Step Three: Analyze the ERDDM data via the Pydro macro

3 *Misc > Run Macro* - browse/select ***ProcSBETDynamicDraft.py*** (should be present in the default directory in the dialog: <Pydro install path>/Lib/site-packages/HSTP/Pydro/Macros)
- Browse to select ERDDM POSProc SBET file--either binary (.out) or ASCII (.txt) will work
- Enter year-doy of start of ERDDM data
- Enter start,end times [units are seconds-of-GPS-week]; it defaults to the min/max of the SBET file
- The data analysis graphs and dynamic draft table appropriate for use in CARIS HIPS will pop up shortly thereafter

Notes:

- While both binary (.out) and ASCII (.txt) POSProc SBET data files may be used, height uncertainty data is not available in the binary files. If you want to use the POSProc height uncertainty, export SBET data to ASCII and process that with the ProcSBETDynamicDraft.py

- The tide correction may take some time, especially in the case of 200 Hz (undecimated) SBET data. The Console Window that accompanies Pydro will show progress, counting through the number of tide look-ups performed. Left at 200 Hz, an dynamic draft calibration SBET file may require on the order of one million tide "corrector" look-ups.

- Figure 1 Ellipsoid Height [m] vs. time is for entire SBET file data; i.e., to help ascertain start,end times to clip the SBET data for all subsequent analysis and plots. Note that this height plot is uncorrected for tide; compare to subsequent graphs which are tide corrected. You may have to select the Figure 1 tab on the Windows system task bar to make it visible on your Desktop.

- Figure 2 Altitude [m] is corrected for tide and records are per start,end clipping.

- Figure 3 is the resulting speed vs. draft appropriate for use in a CARIS HIPS HVF.

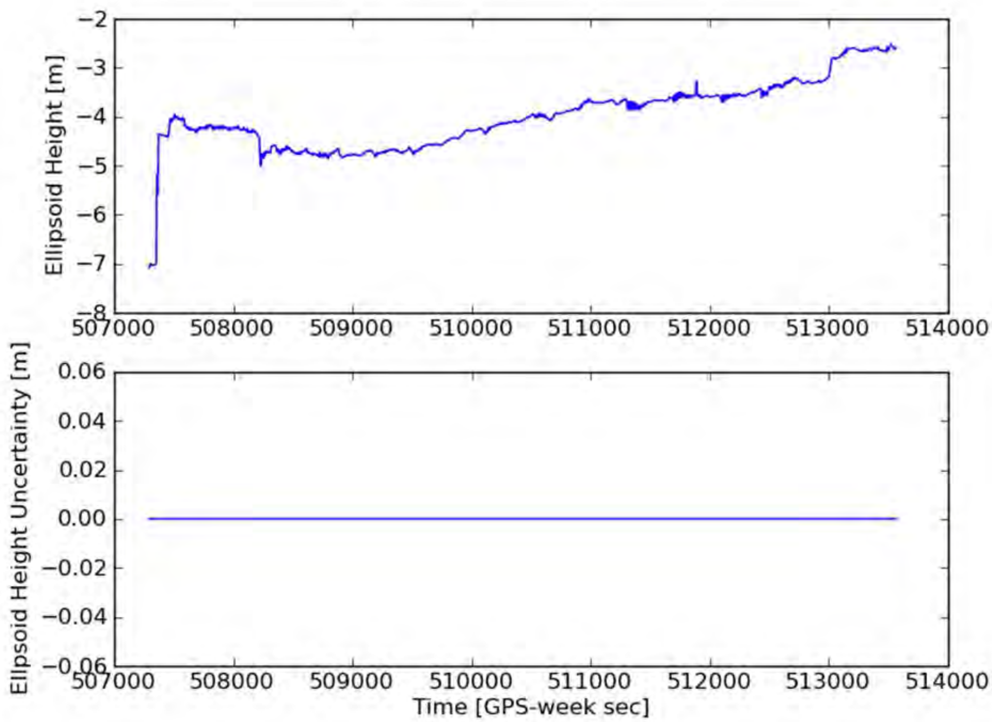

Ellipsoid Height [m]
−2
−3
−4
−5
−6
−7
−8
507000 508000 509000 510000 511000 512000 513000 514000
Ellipsoid Height Uncertainty [m]
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
507000 508000 509000 510000 511000 512000 513000 514000
Time [GPS-week sec]

Figure 1

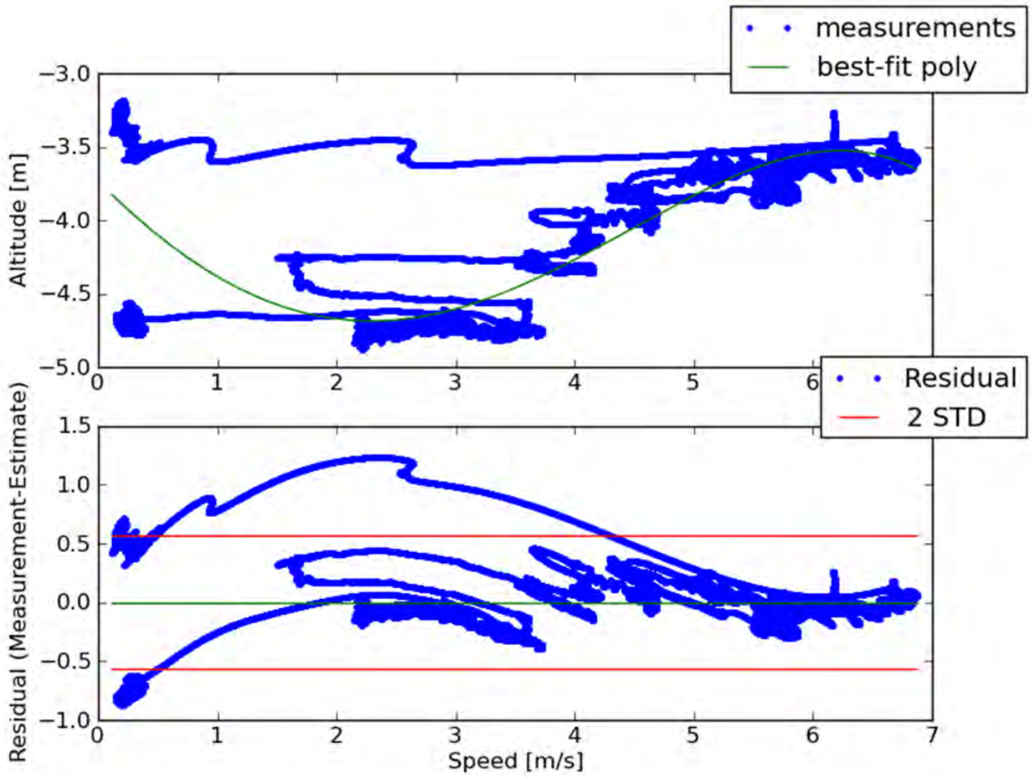


Figure 2 - NO TIDES; 4th-order fit, nominal two-times standard deviation +/-0.6m

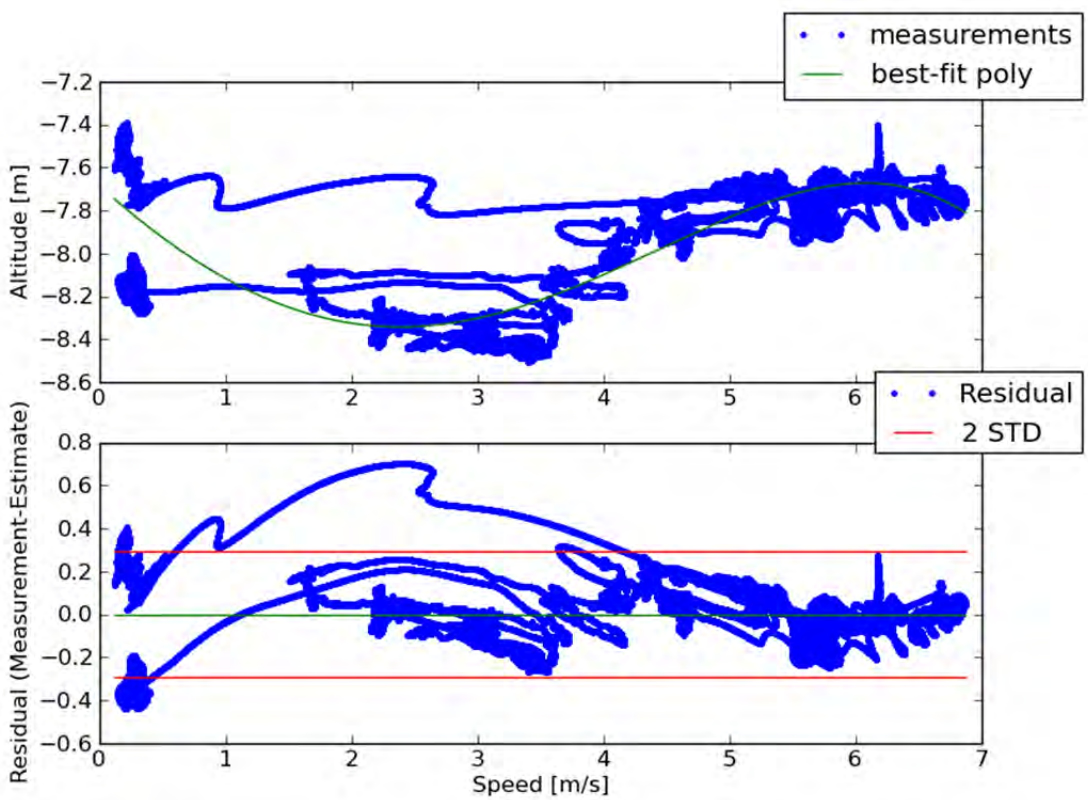
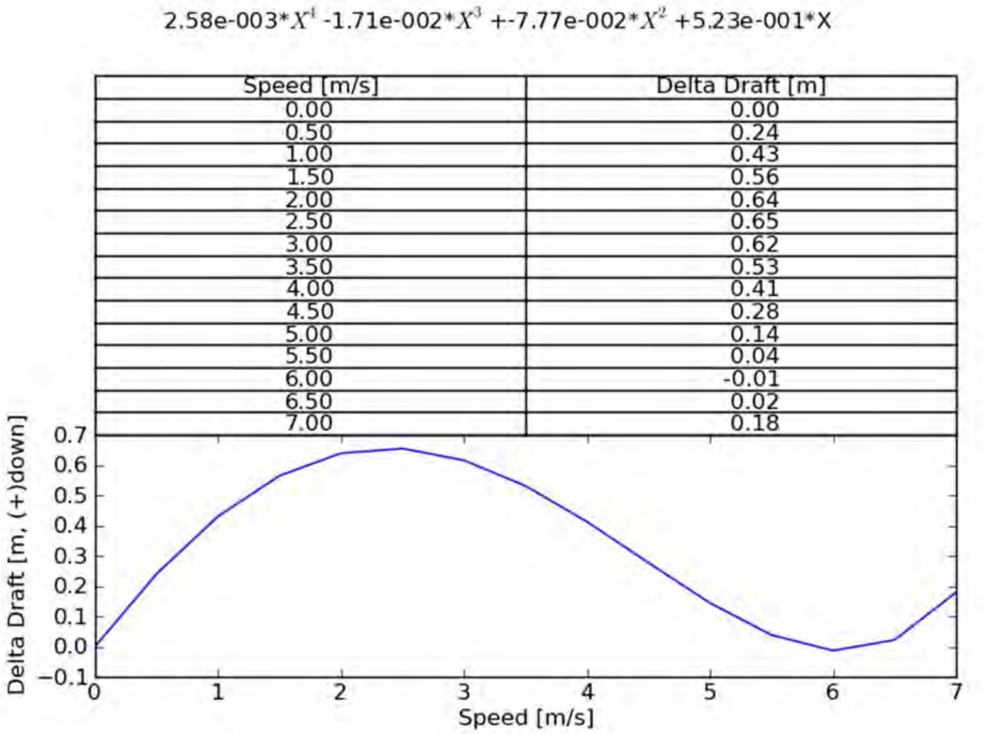


Figure 2 - YES TIDES; 4th-order fit, nominal two-times standard deviation +/-0.3m



$$2.58e\text{-}003*X^4 - 1.71e\text{-}002*X^3 + \text{-}7.77e\text{-}002*X^2 + 5.23e\text{-}001*X$$

Speed [m/s]	Delta Draft [m]
0.00	0.00
0.50	0.24
1.00	0.43
1.50	0.56
2.00	0.64
2.50	0.65
3.00	0.62
3.50	0.53
4.00	0.41
4.50	0.28
5.00	0.14
5.50	0.04
6.00	-0.01
6.50	0.02
7.00	0.18

Figure 3 - YES TIDES; 4th-order fit, dynamic draft table

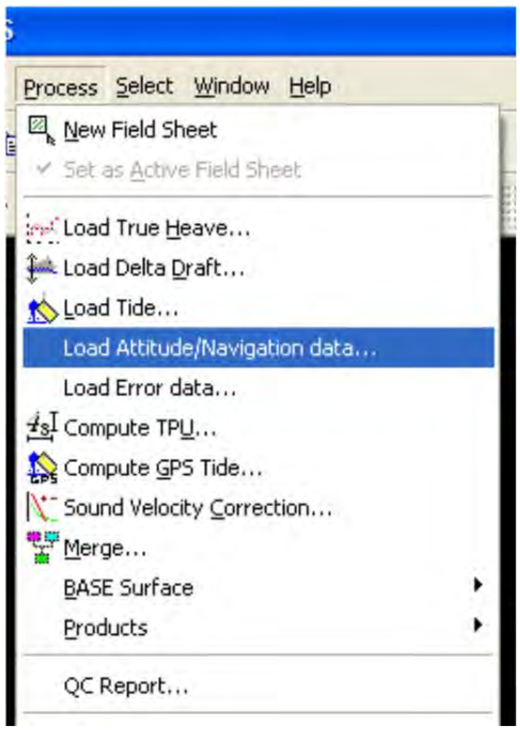
LOADING ATTITUDE/NAVIGATION IN CARIS

Step One: Load Attitude/Navigation Data

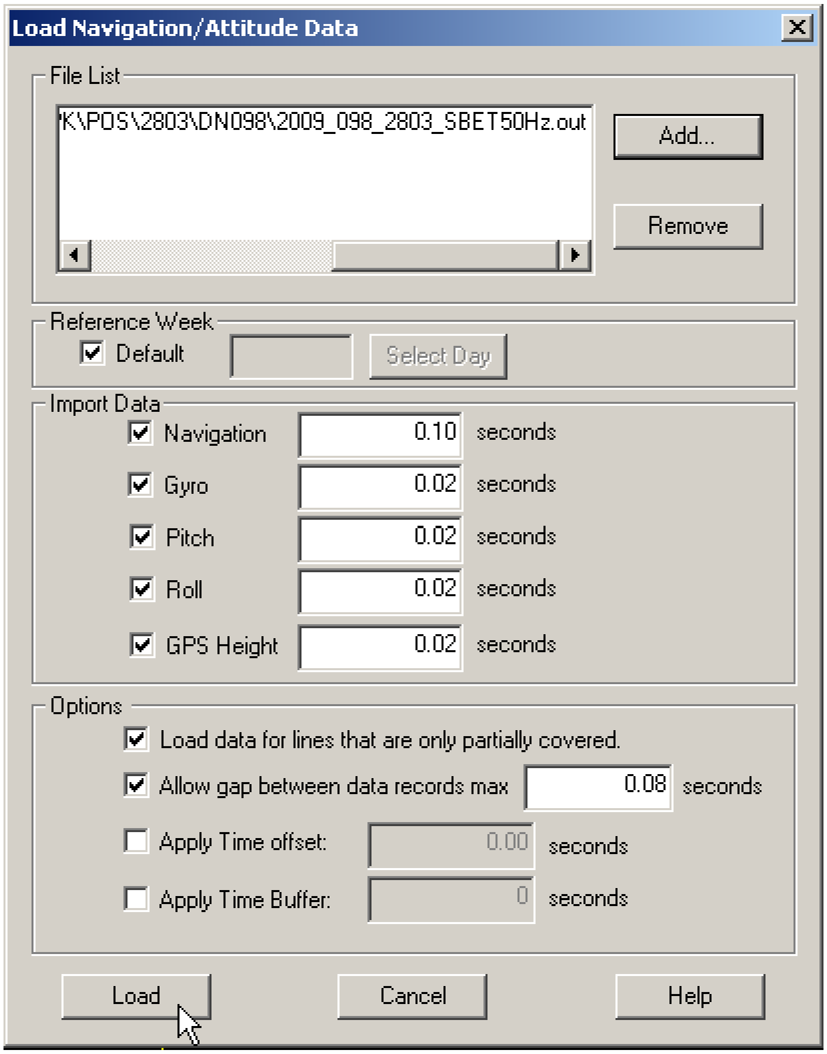
Note: *It is best to this one day or vessel at a time. If you have a day with multiple SBET's add them starting with the end of the day and loading the first one of the day last.*

• In HIPS, select the lines to be loaded with Attitude/Navigation

• Select Process, Load Attitude/ Navigation Data…



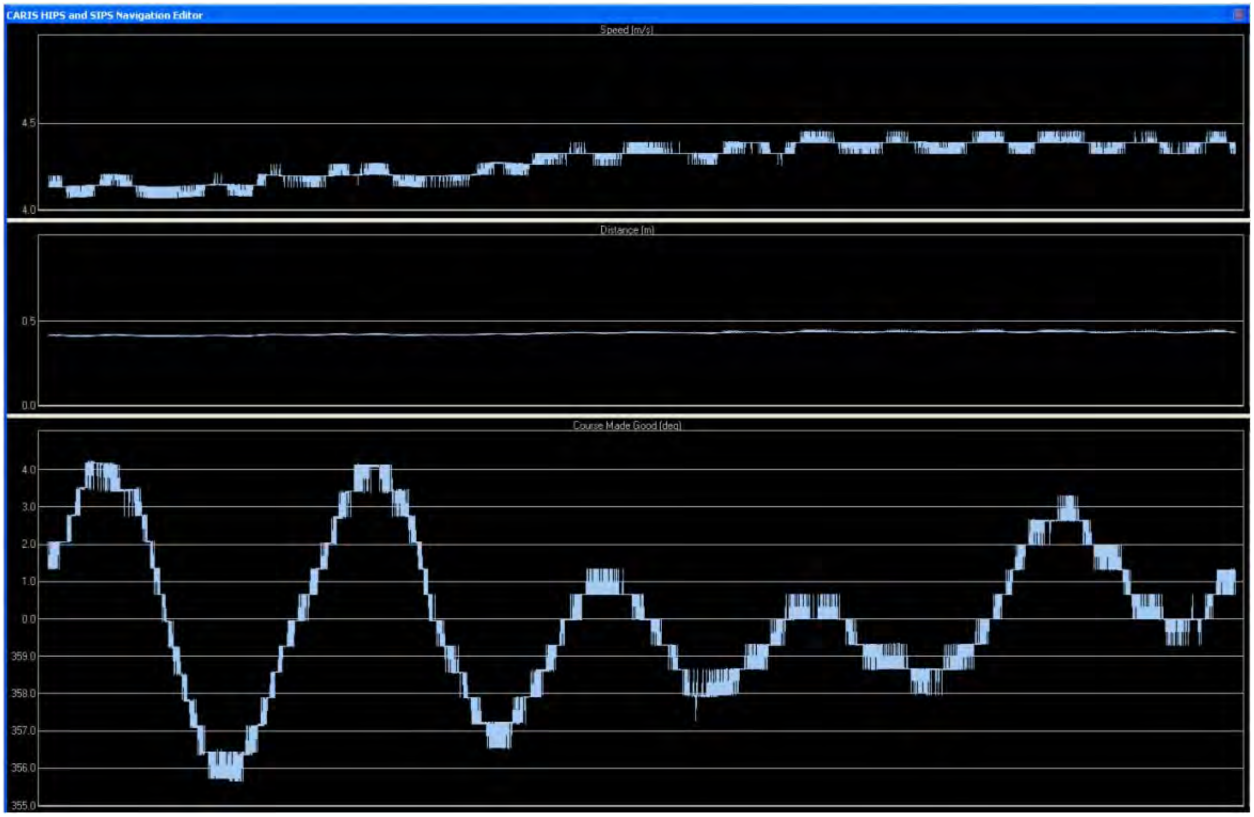
• Click "Add" and select the SBET.out file(s) that correspond to the same time period as the lines being loaded. SBET(s) are found in:
H:\Surveys\HXXXXX\CARIS\SBET\Year_JulianDay_Vessel\Mission 1\Export\Year_JulianDay_Vessel_SBET50Hz.out



• Enter 0.10 seconds for Navigation, 0.02seconds for GPS Height and Allow gap between data records max of 0.08seconds

• Select "Load". **Check the HIPS Output window to ensure no errors are reported**. A correct application will not report an error.

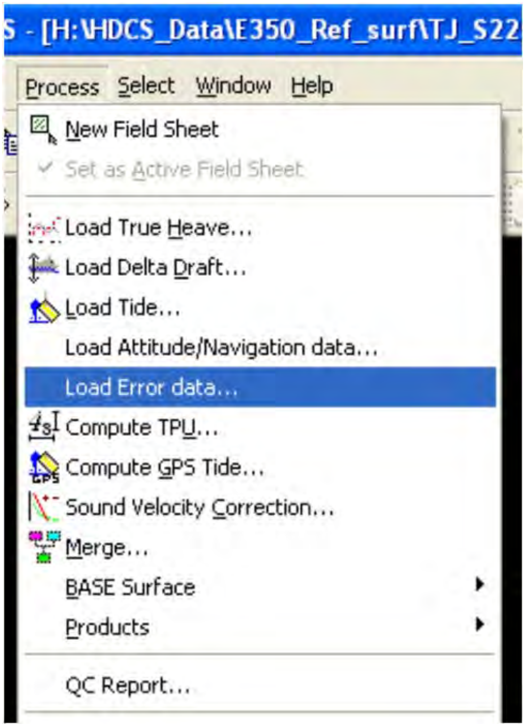
• After applying PPK, lines will need to be re-examined using the Navigation Editor tool in CARIS. Be sure to check for spikes or gaps in Navigation data.


CARIS HIPS and SIPS Navigation Editor
Speed (m/s)
4.5
4.0
Distance (m)
0.5
0.0
Course Made Good (deg)
4.0
3.0
2.0
1.0
0.0
359.0
358.0
357.0
356.0
355.0

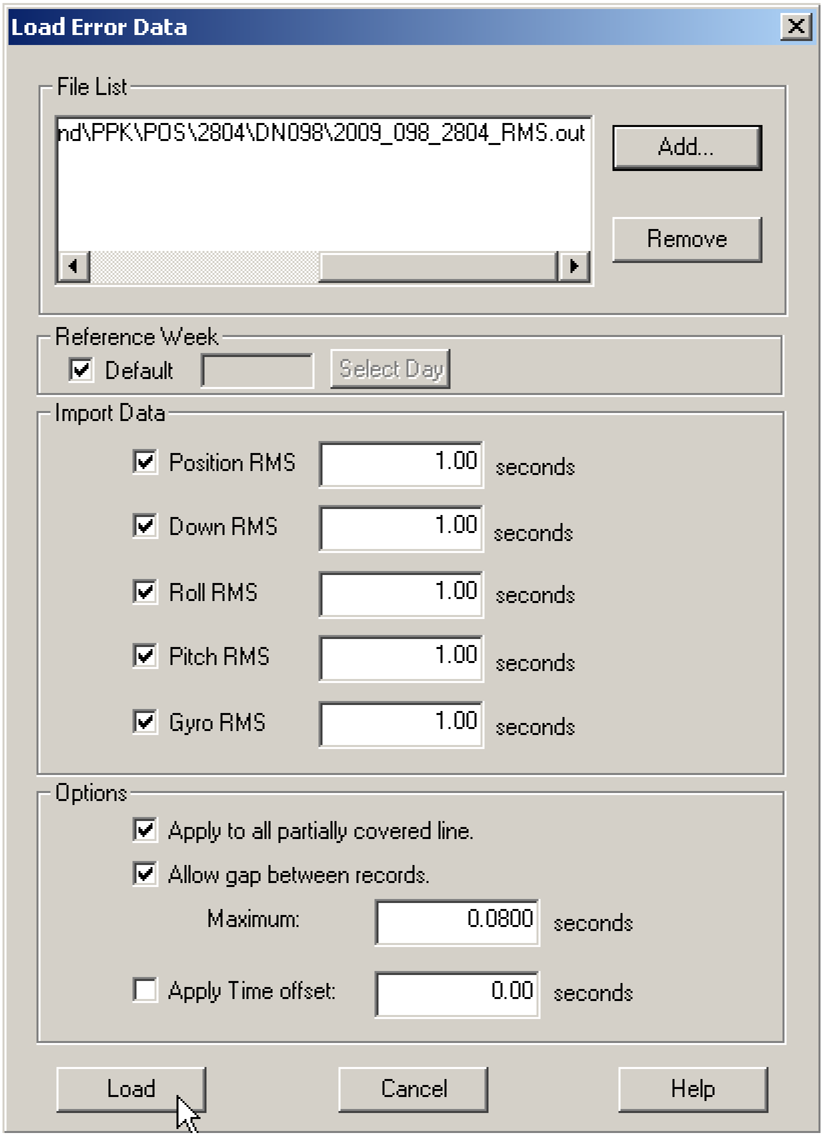
LOADING ERROR DATA IN CARIS

• Select applicable survey lines

• Process, Load Error Data…



• Click “Add…” Browse to H:\Surveys\HXXXXX\CARIS\SBET*Year_JulianDay_Vessel*\Mission 1\Proc*Year_JulianDay_Vessel*_RMS.out



• Under the “Import Data” dialogue box check Position RMS and Vertical Down RMS with a time of 1.00 seconds
• Under the “Options” dialogue box select Allow gap between records with a maximum time of 0.08 seconds
• Click Load

Note: Load Error Data step should be done for both ERS and non-ERS projects. For ERS projects, the post-processed POSPac RMS file (smrmsg) should be used. For non-ERS projects the raw POS PCS file (.000) should be used.

• Be sure to check the CARIS Worksheet window and view the summary report for all survey lines. Make sure there are values for all the areas checked above, and no error reports.

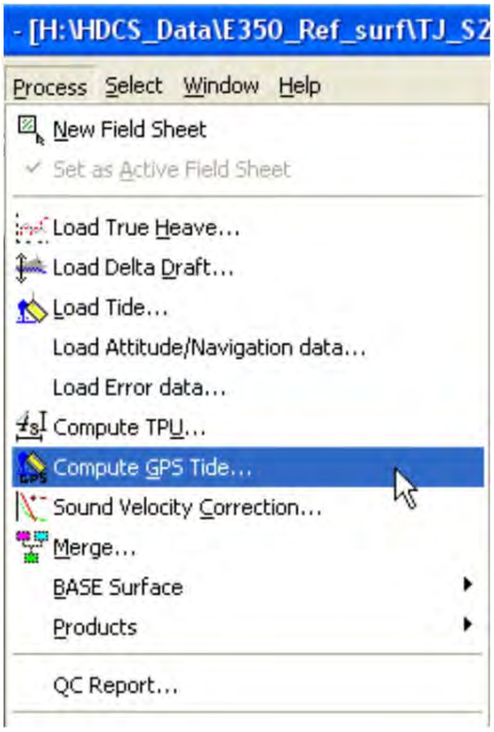
COMPUTE GPS TIDE IN CARIS

Compute GPS Tide

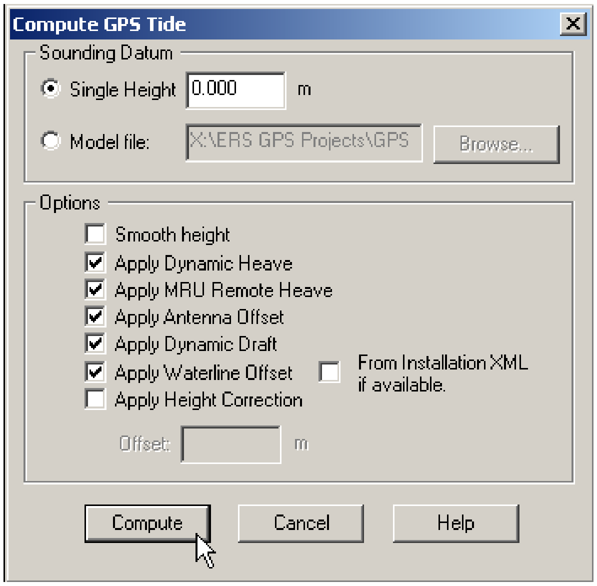
Note: HSD should be providing the VDatum solution offset of Ellipsoid-MLLW. If necessary, this file should be renamed to *ProjectNumber*.txt so it is CARIS compatible. If it is necessary to create your own Ellipsoid-MLLW offset, refer to VDatum tool section in areas where applicable.

• Select all survey lines in CARIS

• Process, Compute GPS Tide…

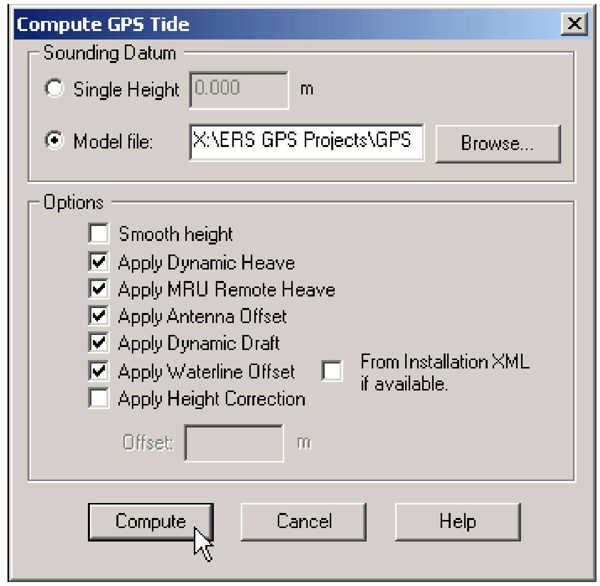


Process Data to the Ellipsoid



• Enter a single height of 0.00m to keep the data referenced to the ellipsoid
• Apply dynamic heave, MRU remote heave, Antenna offset, dynamic draft and waterline offset. See Compute GPSTide reference table
• Click Compute
• Check the output window to ensure no errors occur

Process Data to MLLW using VDatum Model



• Browse to H:\Surveys\HXXXXX\CARIS\SBET folder and select *ProjectName*.txt file
• Apply dynamic heave, MRU remote heave, Antenna offset, dynamic draft and waterline offset. See Compute GPSTide reference table
• Click Compute
• Check the output window to ensure no errors occur

COMPUTE GPS TIDE REFERENCE TABLE

GPS Tide = GPS Height - Datum Height - Dynamic Heave + Remote Heave + Antenna Offset + Dynamic Draft - Waterline + Height Correction

The GPS Tide calculation is dictated according to how components are included in the formulation, if at all (per CARIS HelpDesk - Service Request #00800588):

“Apply” = “Remove”	**GPS Tide Component Option**	**Notes**
	Smooth [GPS] Height	GPS Height time series data may be smoothed according to smoothing coefficients computed in HIPS Attitude Editor.
X	Apply Datum Height	"Apply" to subtract a constant offset or linearly-interpolated offset from a scalar (gridded) field of offsets to achieve the desired (ellipsoid-to-chart) datum transform.
X	Apply Dynamic Heave	"Apply" to subtract dynamic heave from the GPS Height. Select this option to remove dynamic heave from the GPS Height time series. In particular, if heave is applied during HIPS "Sound Velocity Correct", select Apply Dynamic Heave in the GPS Tide calculation to prevent double-compensation of heave motion (assuming heave present in the GPS Height data).
X	Apply MRU Remote Heave	"Apply" to subtract remote heave from the GPS Height. In computing remote heave, HIPS treats the HIPS Vessel File (HVF) reference point (RP) as the center of rigid body rotations for moment arm calculations. Remote heave is that vertical component of the moment arm calculation resulting from an off-RP mounting of the vessel motion reference unit (MRU). Now, MRU remote heave is applied when heave is applied in HIPS "Sound Velocity Correct"; therefore, Apply MRU Remote Heave is necessary only when the Apply Dynamic Heave Option is set (assuming remote heave not already removed from the GPS Height data).

X	Apply Antenna Offset (only meaningful if HVF Navigation ≠IMU)	"Apply" to adjust the GPS Height for roll- and pitch-projected antenna vertical component offset per those x,y,z offsets entered in the Navigation sensor section of the HVF. Note that if the GPS Height was reduced to the HVF RP during data acquisition, the Navigation offsets in the HVF would be zeroed; hence, checking this option would not affect the computation.
X	Apply Dynamic Draft	"Apply" to add dynamic draft affects into the GPS Height time series data. In particular, if the dynamic draft table in the HVF is applied during Sound Velocity Correction (for accurate determination of the initial conditions for geometric ray-tracing) it is necessary to apply dynamic draft in GPS Tide computation.
X	Apply Waterline Offset [Simrad only]: -From Installation XML, if available	"Apply" to adjust the GPS Height to the waterline as per the HVF; optionally, for Simrad, use the waterline value from the installation XML metadata. RP - WL
	Apply Height Correction	"Apply" to add a constant offset to the GPS Height time series data.

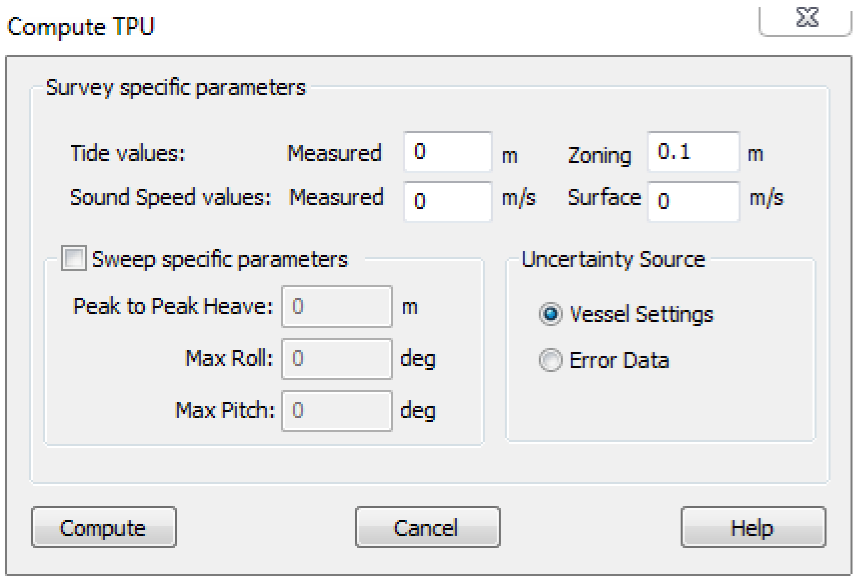
The “Apply” = “Remove” field is to undo what SV Correction initially did to the observed depths if these fields are set to “Apply” = Yes in the HVF. This checking to remove paradigm exists in a Tide/ERS scenario, in a strait ERS paradigm the HVF could be modified to “Apply”=NO at the project’s onset.

COMPUTE GPS TIDE IN CARIS

Compute GPS Tide
Note: HSD OPS will provide the VDatum SEP Uncertainty values in the project instructions.

• Select all survey lines in CARIS

• Process, Compute TPU…

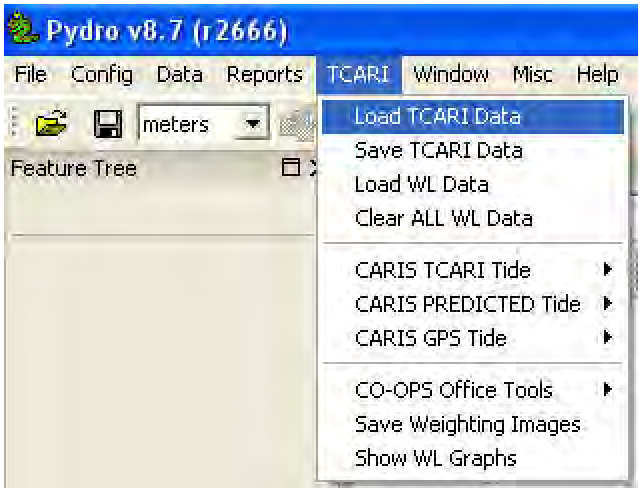


Currently, CARIS does not have a process or placeholder for the separation model uncertainty, so the following is our current workaround. Input the one sigma VDatum maximum combined uncertainty value provided in the project instructions into the Tide Values: Zoning (e.g 0.10m).

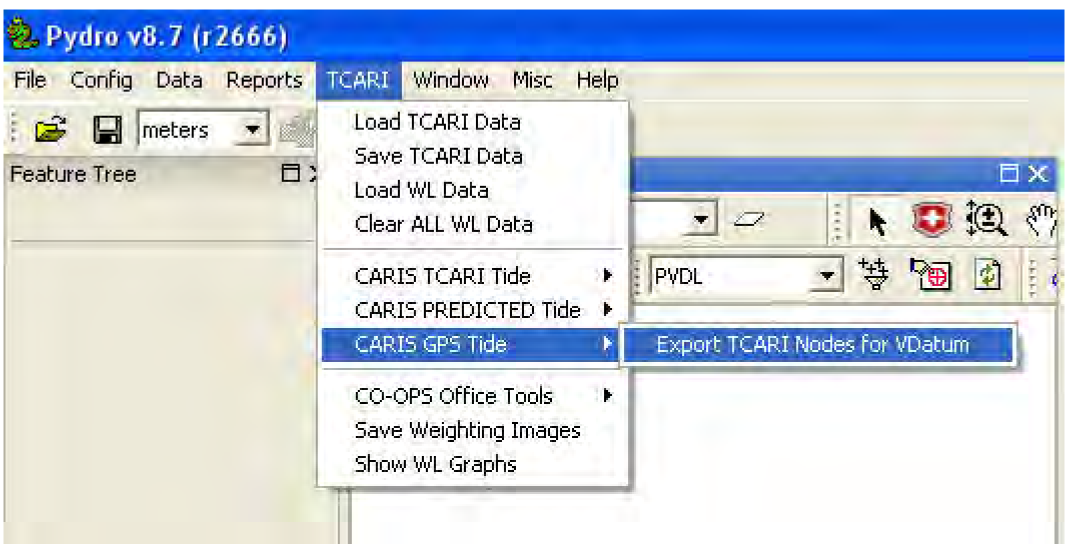
VERTICAL DATUMS TRANSFORMATION TOOL (*VDatum*)

Once you load Attitude/Navigation, your bathy data is referenced to the ellipsoid. We'll need to prepare a file to be run through VDatum to provide your Ellipsoid-MLLW offset. Launch Pydro.

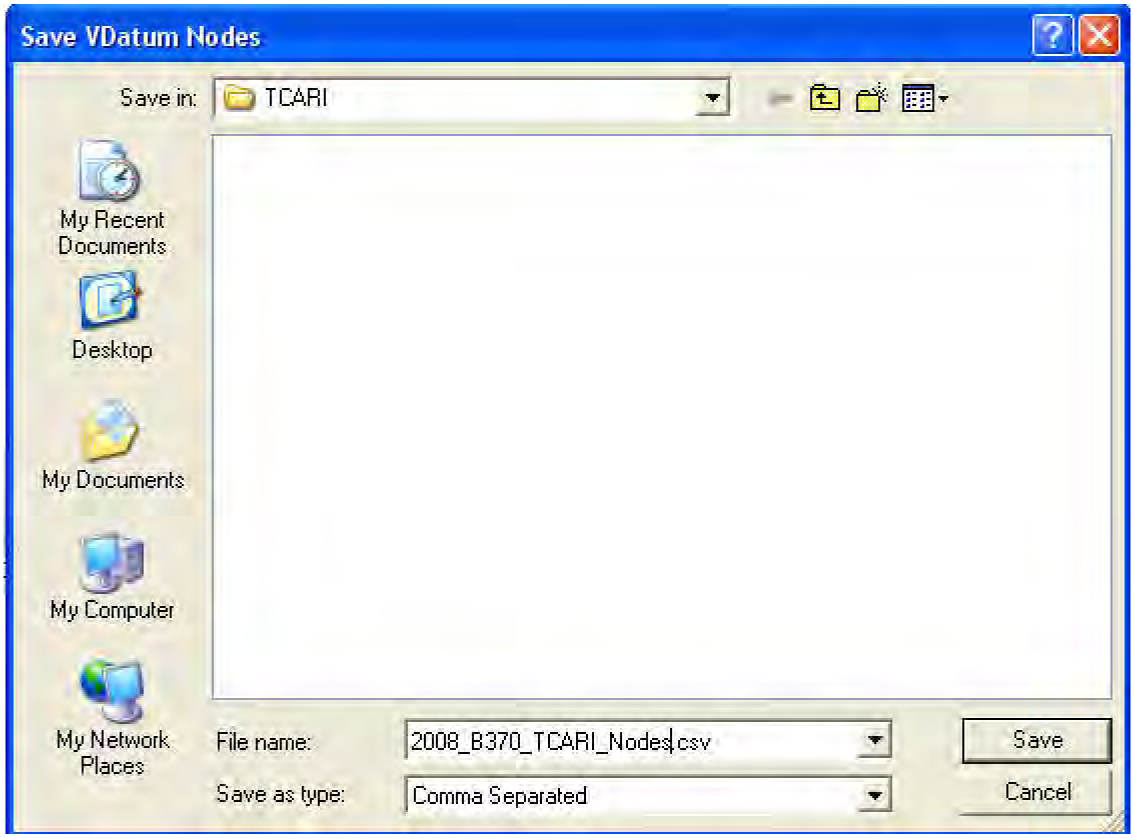
1. Select TCARI/Load TCARI Data



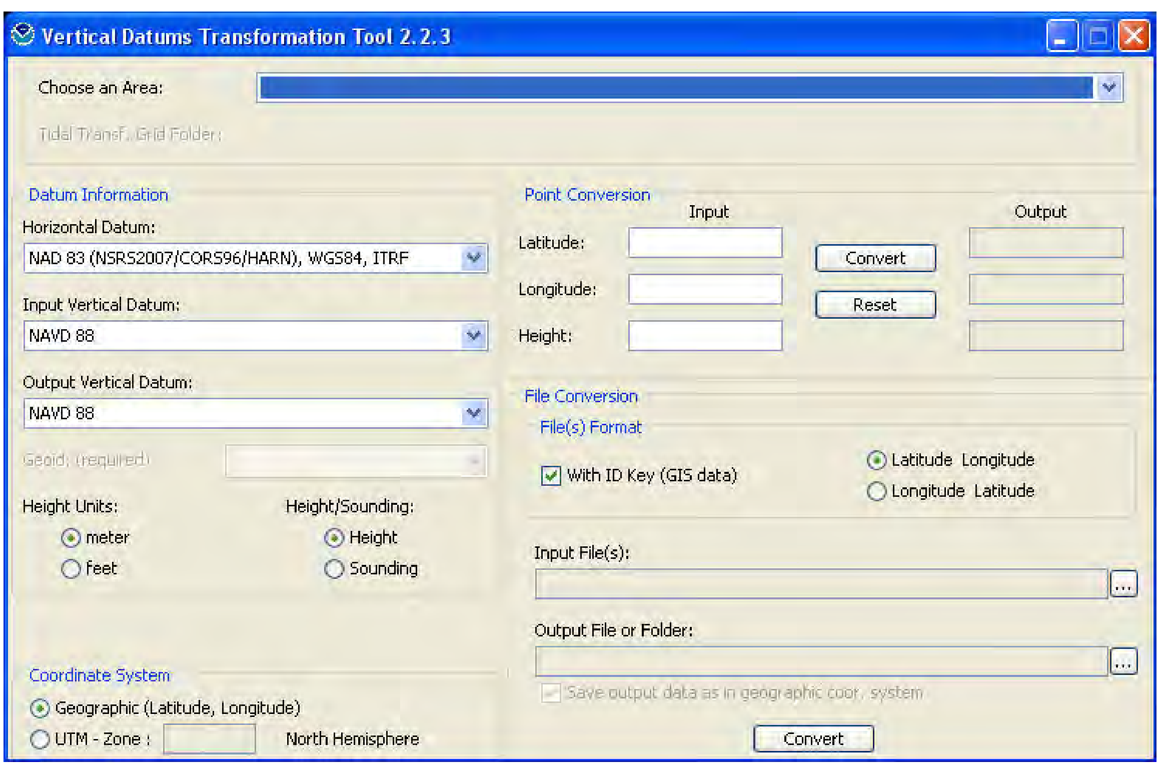
2. Select TCARI/CARIS GPS Tide/Export TCARI Nodes for VDatum



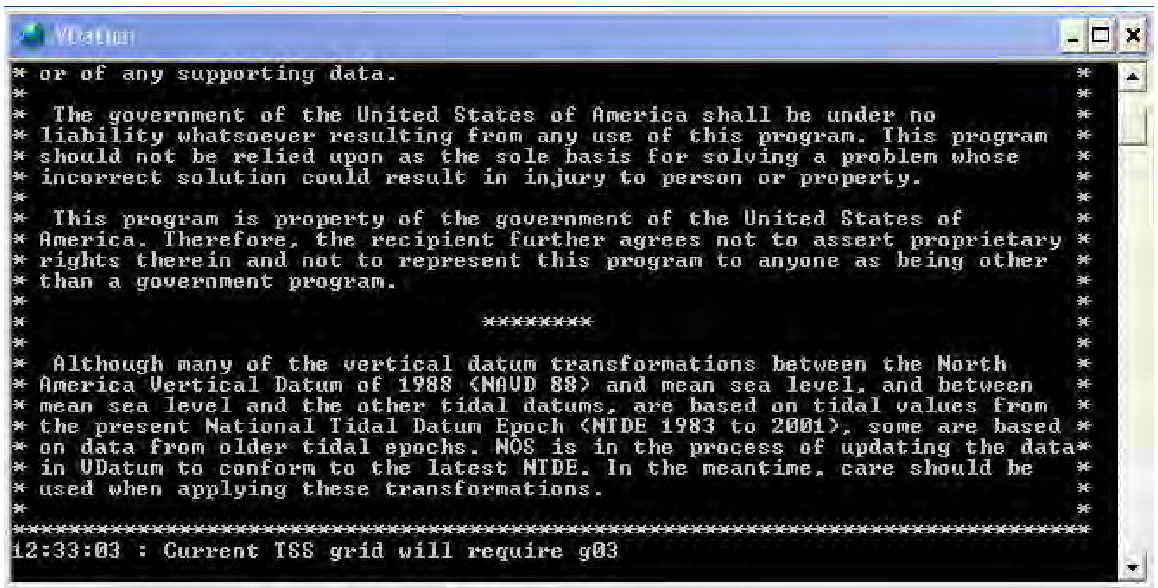
3. Save file as "Year_Project Number_TCARI_Nodes.csv"



Launch the VDatum Transformation Tool by double clicking "VDatum_v2.bat"
The following windows will open:

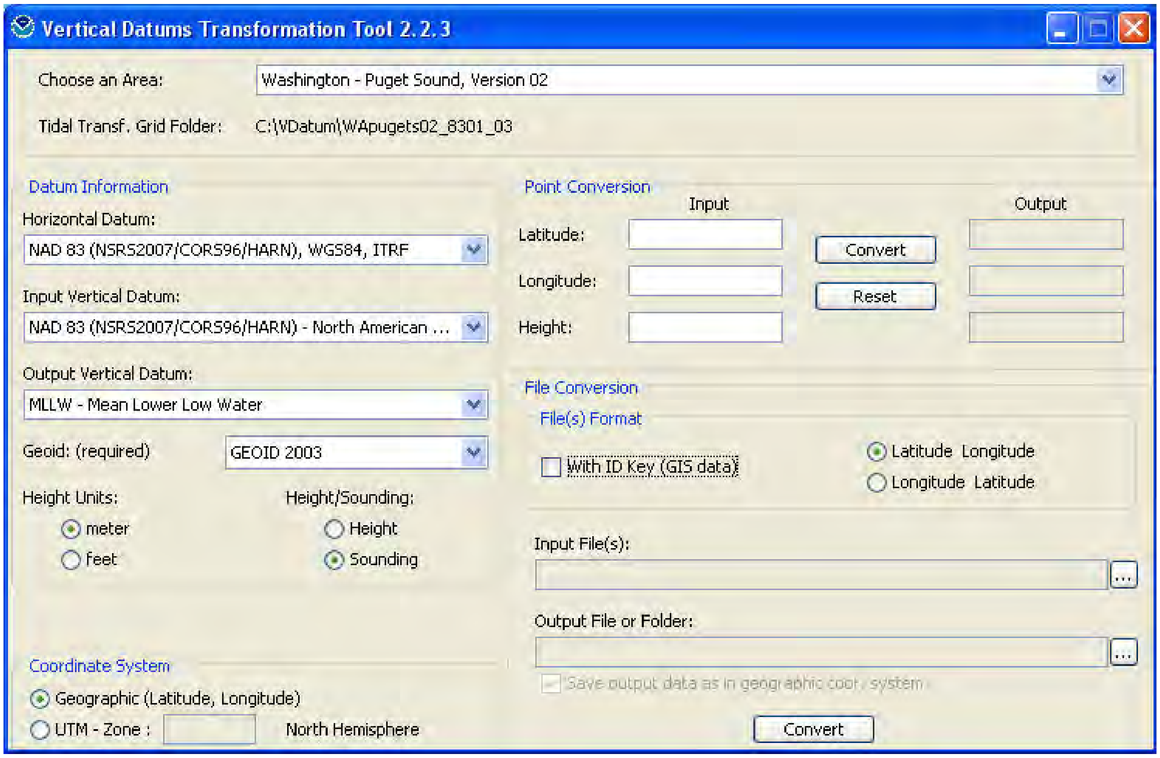


4. Choose the correct area that corresponds to the sheet boundaries.
5. Transformation Grid Folder will be left as the default setting
6. Under the “Datum Information” dialogue box choose the correct Horizontal Datum **“NAD 83 (NSRS2007/CORS96/HARN), WGS84, ITRF”**
7. Input the correct Vertical Datum **“NAD 83 (NSRS2007/CORS96/HARN) – North American**
8. Select the correct Output Vertical Datum. **MLLW – Mean Lower Low Water**
9. In this case the Geoid will be set to **GEOID 2003,** but check the command prompt VDatum Window and verify “Current TSS grid will require g03



10. Height Units will be in meters
11. Under the “Height/Sounding” option check **Sounding**
12. Under the “Coordinate System” dialogue box choose **Geographic Coordinate System**
13. Nothing will be inserted under the “Point Conversion” dialogue box
14. Under the “File Conversion” dialogue box, uncheck “With ID Key (GIS data)” and select **Latitude Longitude**
15. Under “Input” File select the .csv that was output from Pydro (ex. “Year_Project Number_TCARI_Nodes.csv”) The Output File or Folder option will automatically be selected to create the file in the same folder as the .csv file, and the file should be named “Year_Project Number_Ellip_MLLW.csv.”

After the following selections have been made, the Vertical Transformation window will look like the following:


Vertical Datums Transformation Tool 2.2.3
Choose an Area:
Washington - Puget Sound, Version 02
Tidal Transf. Grid Folder:
C:\VDatum\WApugets02_8301_03
Datum Information
Horizontal Datum:
NAD 83 (NSRS2007/CORS96/HARN), WGS84, ITRF
Input Vertical Datum:
NAD 83 (NSRS2007/CORS96/HARN) - North American ...
Output Vertical Datum:
MLLW - Mean Lower Low Water
Geoid: (required)
GEOID 2003
Height Units:
meter
feet
Height/Sounding:
Height
Sounding
Coordinate System
Geographic (Latitude, Longitude)
UTM - Zone :
North Hemisphere
Point Conversion
Input
Output
Latitude:
Longitude:
Height:
Convert
Reset
File Conversion
File(s) Format
With ID Key (GIS data)
Latitude Longitude
Longitude Latitude
Input File(s):
Output File or Folder:
Save output data as in geographic coor. system
Convert

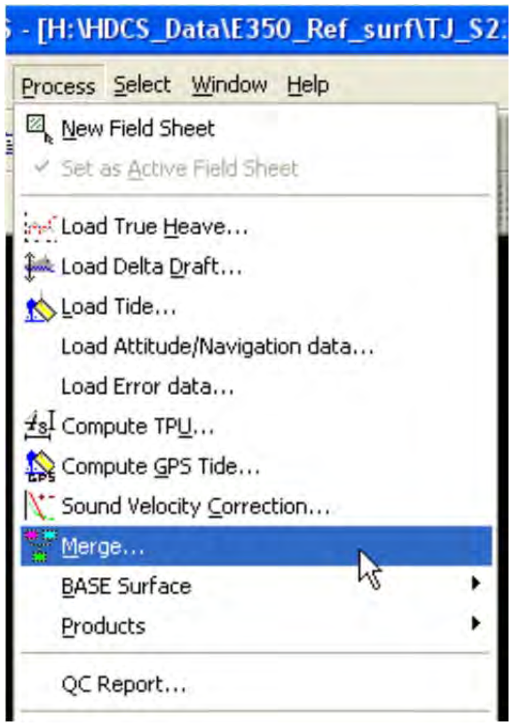
ELLIPSOIDALLY REFERENCED ZONED TIDES

An alternative option in areas lacking a published VDatum model is to relate "traditional" zoned water levels to the ellipsoid. This is done by measuring the height of the GPS antenna to the water line. Then a SEP is created by adding this ellipsoidally-referenced water line measurement to the zoned water level “corrector.” The SEP is then applied to the ellipsodially-referenced hydrography to reference it to chart datum. ERS-ERZT data may be readjusted at a later date when VDatum coverage becomes available. Additional tools and documentation will be made available via a Hydrographic Technical Directive later this year.

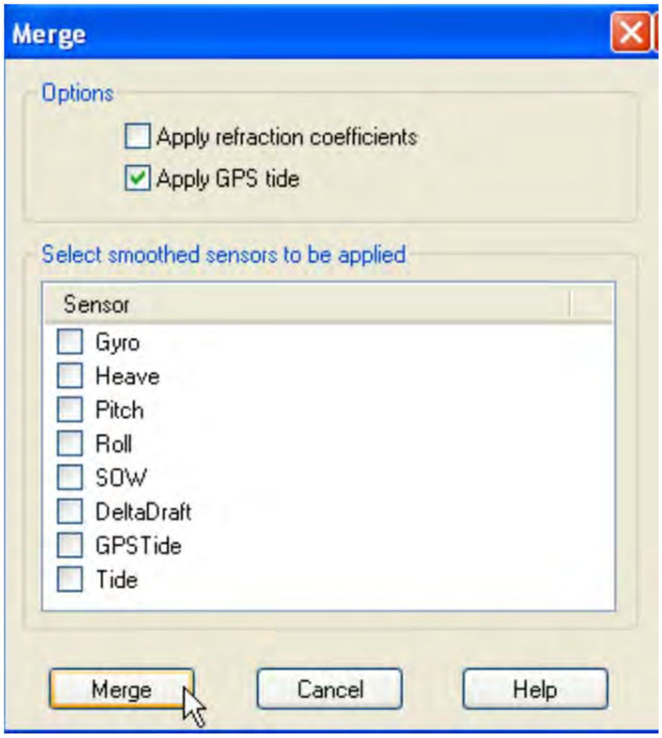
MERGE IN CARIS

• Select all applicable lines

• Process, Merge



• Check “Apply GPS Tide”



Note: To go back to MLLW with tides applied, remerge the lines with “Apply GPS tide” *unchecked*

HORCON / VERCON OBSERVATION LOG

DATE: **SESSION:**

WX CONDITIONS:

OBSERVER(S):

DN:

4 CHAR. SITE ID:

SESS. FILE NAME:

ELEV. MASK: ________degrees

RECORDING INTERVAL:__________sec.s

PROJECT NAME:

SITE NAME: ____________________ **SITE PHOTO(S): Y / N**

SITE TYPE: HORZ. / VERT. / ATON / BM / NEW / ______________

RECEIVER #: ______________________ **FIXED HEIGHT? Y / N**

ANTENNA #: **SPACER? Y / N**

ANT. MEASUREMENTS		**ANT. CONSTANTS**	
ANT. SLANT HEIGHT **(S)**		ANT. RAD. **(R)**	V. OFFSET **(C)**
START	STOP		
________ m	________ m	________ m	________ m
________ ft	________ ft		

OBSERVATION TIMES AND STATUS

RECEIVER TIME (UTC)	PDOP	LOCAL TIME	# of SV's	POWER
START:				
STOP:				

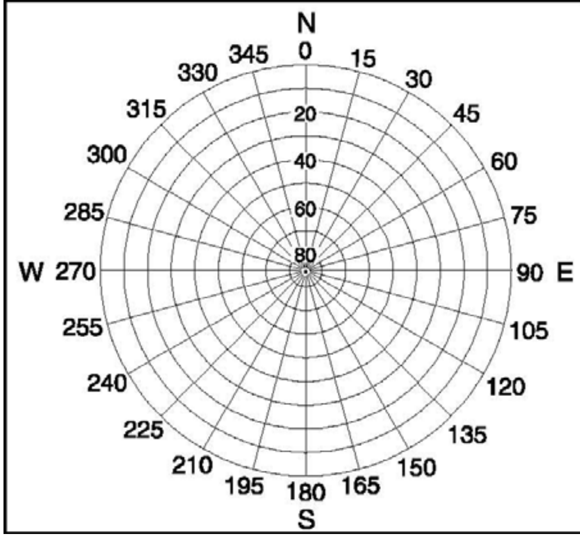
INSTRUCTIONS:

Office Check by:

HI to ARP=((SQRT(S^2-R^2) – C): **(m)**

SITE SKETCH/LOC./NOTES:

OBSTRUCTION DIAGRAM



MONUMENT RUBBING / DESCRIPTION

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length **(A)** and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) **(B)**

$$Antenna.Height = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm				
Before, inch				
After, cm				
After, inch				
Note: cm= inch x (2.54)	Overall average, cm			

S = ________________ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

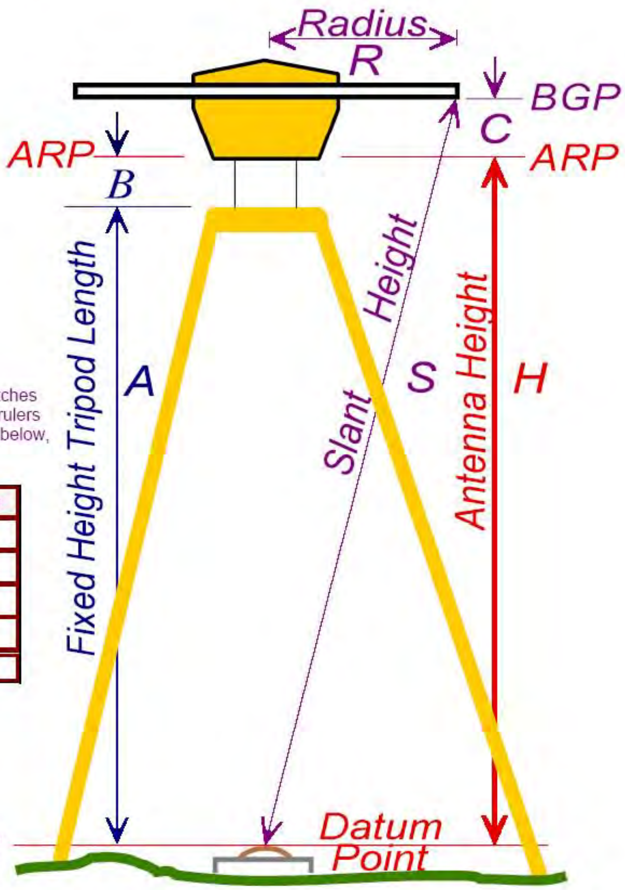
R = ________________ cm

C = ________________ cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$Antenna.Height = H = ((\sqrt{S^2 - R^2}) - C)$$



SBET QUALITY CONTROL LOG

Sample:

	A	B	C	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1			Imported				Smoothed Performance Metrics	Calibrated Install Parmeters			Solution Status	Smoothed-Reference Data						
2	DN	POSPAC Project Name	POSMV File	Processed	Remarks	Stations Used	H/V	X Ref Pri	Y Ref Pri	Z Ref Pri	Solution	N/S	E/W	Down	Recommendation	Remarks	QC Review	Transferred
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
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20																		
21																		
22																		

Table 4-9. Uncertainty values for use in CARIS with vessels equipped WITH an attitude sensor

Entry in HVF		1 Sigma Recommended Value	(Units)
Attitude			
Gyro error (heading)	for POS/MV 320	0.02	deg
Heave (amplitude)*	for POS/MV 320	5	%
Heave *	for POS/MV 320	0.05	m
Roll	for POS/MV 320	0.02	deg
Pitch	for POS/MV 320	0.02	deg
Nav. position	0.5 to 2.0 depending on differential quality	1	m
Sonar timing			
Nav. Timing**	Integration dependent	.01	(.005)s
Gyro Timing**	Integration dependent	.01	(.005)s
Heave Timing**	Integration dependent	.01	(.005)s
Pitch Timing**	Integration dependent	.01	(.005)s
Roll Timing**	Integration dependent	.01	(.005)s
Vessel variables			
Offsets (x, y, z)	mm to dm depending on measurement accuracy		m
Vessel speed	0.03 plus average current in the area (used for dynamic draft table entry)		m/s
Loading	Range = 1cm to 30cm, dependent on vessel, fueling frequency and frequency of draft measurement.		m
Draft	Range = 1cm to 20cm, depends on how accurately draft may be read (sight glass, six inch draft marks, etc)		m
Delta draft	Range = 1cm to 3cm, dependent on methodology and magnitude of effect		m
MRU alignment (yaw)	Uncertainty in the patch test offset value determined for transducer yaw. (Standard deviation of several calibration iterations) [Multibeam boats only]	<1	deg
MRU alignment (roll/pitch)	Uncertainty in the patch test offset value determined for transducer pitch/roll. (Standard deviation of several calibration iterations) [Multibeam boats only]	<1	deg
Entry in TPE Controller Window		**1 Sigma Recommended Value**	**(Units)**
Tides			
Measured	Range (0.01m - 0.05m) dependent on gauge accuracy and duration of deployment		m
Zoning (discrete)	Range (0.01m - 0.40m) dependent on distance from gauge, range of tide, rate of tide change, and meteorological factors. Value provided by CO-OPS in the tide document in the project instructions package.		m
Zoning (TCARI)	TBD		m
Sound Speed			
Measured	Range (0.5m/s to 4 m/s) dependent on spatial and temporal variability Use 1 m/s for casts every 15 min or less Use 4 m/s for casts every 4 hours		m/s
Surface	Range (0.2 m/s to 2 m/s): dependent on surface sound speed gradient		m/s

*Note: For heave accuracy must use the larger value of 0.05m or 5%.
**Note: All timing depends on integration: serial connections = 0.01s, ethernet with precise timing = 0.005s.

Table 4-10. Uncertainty values for use in CARIS with singlebeam vessels WITHOUT an attitude sensor

Entry in HVF		1 Sigma Recommended Value	(Units)
	Attitude		
Gyro error (heading)	Dependant on crab angle and boat handling conditions	5-20	deg
Heave (amplitude)	N/A	0	%
Heave	Based on heave experienced in the field	0.707*(heave amplitude)	m
Roll	N/A	0	deg
Pitch	N/A	0	deg
Nav. position	0.5 to 2.0 depending on differential quality	1	m
	Sonar timing		
Nav. Timing	Integration dependent	.01	s
Gyro Timing	N/A	0	s
Heave Timing	N/A	0	s
Pitch Timing	N/A	0	s
Roll Timing	N/A	0	s
	Vessel variables		
Offsets (x, y, z)	mm to dm depending on measurement accuracy		m
Vessel speed	0.03 plus average current in the area (used for dynamic draft table entry)		m/s
Loading	Range = 1cm to 30cm, dependent on vessel, fueling frequency and frequency of draft measurement.		m
Draft	Range = 1cm to 20cm, depends on how accurately draft may be read (sight glass, six inch draft marks, etc)		m
Delta draft	Range = 1cm to 3cm, dependent on methodology and magnitude of effect		m
MRU alignment (yaw)	N/A	0	deg
MRU alignment (roll/pitch)	N/A	0	deg
Entry in TPE Controller Window		**1 Sigma Recommended Value**	**(Units)**
	Tides		
Measured	Range (0.01m - 0.05m) dependent on gauge accuracy and duration of deployment		m
Zoning (discrete)	Range (0.01m - 0.40m) dependent on distance from gauge, range of tide, rate of tide change, and meteorological factors. Value provided by CO-OPS in the tide document in the project instructions package.		m
Zoning (TCARI)	TBD		m
	Sound Speed		
Measured	Range (0.5m/s to 4 m/s) dependent on spatial and temporal variability Use 4 m/s for casts every 4 hours For less frequent casts, estimate variability of the area and use an appropriate value		m/s

S-57 and NOAA Attribution Guidance

S-57 Required Attribution

The following tables will serve as guidance and reference on S-57 Required Attribution.

<table>
<tr><th>Attribute</th><th>Description</th></tr>
<tr><td>All Feature Objects:</td><td>ALL surveyed objects will have the following attributes populated.</td></tr>
<tr><td>SORIND (Source indication)</td><td>• Country code – US
• US Authority code - US for OSC
• Source – graph
• ID code - registry number
• Ex: US,US,graph,H12345</td></tr>
<tr><td>SORDAT (Source Date)</td><td>The last day of survey acquisition formatted as YYYYMMDD</td></tr>
<tr><td colspan="2">Instances which require altering SORDAT and SORIND:
• New feature
• Modification to the geographic position of a feature
• Modification to the geometry (shape) of a feature
• Modification to the geographic primitive of a feature (example: point becomes line)
• Modification to a feature’s object class
• Modification or addition to a feature’s attribution</td></tr>
<tr><td colspan="2">Note: Disproved and Retained features will always maintain the original SORDAT and SORIND</td></tr>
</table>

NOAA Required Attribution

The following is a list of customized NOAA attributes for new, updated, and disproved features. The Attribute column is divided into separate columns for equivalent attributes within CARIS, HYPACK and Pydro.

Attribute		Description
CARIS & HYPACK	**Pydro**	

descrp	**Chart**	Portrays the field charting action.
		• New - New features or new positions
		• Updates - Modification of attribution, geometry, and/or feature object class
		• Delete – Disproval's or erroneous features. Examples include situations where:
		  o Feature no longer exists
		  o Geographic position is altered
		  o Geographic primitive is altered (i.e. point feature modified to a line; point modified to an area, etc.)
		• Retain – Addressed items that are represented properly on the chart. A remark should be included for informational purposes as necessary
		• Not Addressed - For items that were 'assigned' by the HSD Operations Project Manager or COTR but that were not addressed. Include remark describing why the feature was not addressed

prmsec	**Status**	Indicates the status of the feature and is particularly helpful during side scan sonar processing. The status is used to associate new items that correlate to a given real world feature, or lack thereof in the case of disproving the existence of a charted feature. • Primary - principal feature that can be associated with one or more secondary features. The primary feature is always the feature with the most accurate position and least depth (if applicable). • Secondary - Signifies that the feature is correlated to the primary. • Pending - a tool used during data processing. There should be no features left as pending once a survey is complete.
Note: • Features that have only one observation are also labeled primary.		

• The final Primary item should be either based on bathymetry data or a DP, unless the item is insignificant or significance could not otherwise be determined before the termination of data acquisition. • In Pydro the software status defaults to Pending for all items inserted or otherwise created in Pydro. Relative status levels can be assigned for sets of spatially correlated or grouped items. No Pending items shall remain in the Pydro PSS file for a completed survey submitted to AHB or PHB. • In CARIS and HYPACK if the prmsec is populated with '2- Secondary' prkyid must also be populated. See prkyid attribute below for further information.		
remrks	**Remarks**	Used to provide additional information about features that is not captured elsewhere in the digital data (e.g. S-57 attribution).The hydrographer's feature remarks should include what the feature is and what techniques were used to identify the feature.
Note: • Only the primary item representing the feature requires a remark, but the remark may often contain information about the secondary items as well. • Remarks shall be written either in longhand or using the standard abbreviations tabulated in Appendices IV.		
recomd	**Recommendations**	Provides survey data reviewers and cartographers additional information about a feature. While explicit charting recommendations are not mandatory it is important to clearly communicate all information necessary to ensure proper charting of a feature.
Note: • Only required for new features and charted feature disproval's. • Do NOT include exact geographic positions (Latitude and Longitude), least depths, etc. in Remarks or Recommendations. However, the practice of including the correlating AWOIS number (RECRD field) in the remarks is acceptable.		
sftype	**Keyword, DToN**	Indicates a feature with a special designation • ATON - ATON investigations • AWOIS - AWOIS investigations • DTON - Dangers to Navigation • Maritime Boundary – Maritime Boundary investigations • CEF – Cartographic Evaluation File
Note: • Only required for special feature type objects. • In Pydro items can be marked as DTON only if they are first flagged Chart.		

NOAA Discretionary Attribution

The following is a list of additional NOAA Customized Attributes that are recommended, but now mandatory.

<table>
<tr><th colspan="2">Attribute</th><th>Description</th></tr>
<tr><th>CARIS
&
HYPACK</th><th>Pydro</th><th></th></tr>
<tr><td>asgnmt</td><td>Keyword</td><td>Indicates assignment status of items delivered to the field by the project manager from HSD Operations.
• Unassigned
• Assigned
• For Info Only</td></tr>
<tr><td>images</td><td></td><td>Images associated with a feature are used to document an individual
feature (i.e. such as screen-grabs, side scan snapshots, or digital photos).</td></tr>
<tr><td colspan="3">Note:
• The required format for all images including 3-D graphics and photos shall be JPEG.
• A standard naming convention: <Hxxxxx_3D_a.jpg> for 3-D images and <Hxxxxx_Photo_a.JPEG> for photos shall be used.
• If more than one image is required, files shall be named in sequence starting with the letter 'a' <H12345_SSS100a_1m.tif>.
• All images (including SSS contact images) and photographs should be placed in the Multimedia folder. A copy of the side scan sonar contact images should remain in the CARIS HDCS folder.</td></tr>
<tr><td>keywrd</td><td>Keyword</td><td>Customized word used for processing or querying data. Users can expand the set of attributes and flags by making Keyword assignments to features under the Keyword tab or attribute.</td></tr>
<tr><td colspan="3">Note:
In Pydro, once a new Keyword is added in the Editor’s Notebook, it is available to assign to other features within the PSS. Standard Keyword values pre-defined in Pydro include “Assigned”, “Bottom Sample”, “ATON” and “AWOIS”.</td></tr>
<tr><td>acqsts</td><td>Investigate and Resolved</td><td>A tracking tool used during data processing that ensures features are fully investigated as necessary.
• Investigate - indicates that further field examination and analysis are required.
• Resolved - indicates that field examination and analysis have been completed for an item.</td></tr>
<tr><td colspan="3">Note:</td></tr>
</table>

• The Final Feature File (.hob, .000, or .pss) to be submitted to AHB or PHB shall not contain any Unresolved items. • The Investigate flag and attribute enables the direct export of specific items to MapInfo MIF/MID, HYPACK TGT, and .000 format for planning further investigation or development.		
invreq	**Remarks**	The project manager at HSD OPS uses this field to define specific investigation requirements for the field. There may be specific requests from customers about particular features, or questionable features that may warrant extra attention.
prkyid		The primary key ID shall be populated for secondary features with the primary feature's Database key ID (i.e. when prmsec = secondary). This is a means for manual correlation in CARIS and HYPACK.
userid	**DispName**	The unique ID shall be populated with a unique name or number. This attribute is used as a unique identifier instead of the dbkyid (Database Key ID) in CARIS because the dbkyid can change during imports and exports.

Additional Pydro Flags

The following is a list of additional flags in Pydro to support data processing and analysis:

Pydro Flag	Description
Submitted	Denotes that items flagged as Primary+Chart+DTON have been exported from Pydro to a DTON report for submission to MCD. Once marked Submitted, these items will not be re-exported during creation of subsequent DTON reports unless the "Submitted" flag is manually cleared prior to generating the report.
Office QC	Denotes that AHB/PHB examination and verification have been completed for an item. The Pydro PSS for a completed survey to be submitted to HSD or otherwise archived shall not contain any Primary items that are not flagged Office QC. This is a Processing Branch tool only.
Rejected	Identifies any item that the hydrographer does not want included in the survey. Any pertinent information explaining why the feature has been rejected should be included under the Remarks tab of the Editor's Notebook. Rejecting an imagery feature in Pydro will flag the corresponding SIPS contact as rejected, but will not delete the contact. Rejecting a bathymetry feature in Pydro will clear the Outstanding flag in HIPS, but will not reject the corresponding sounding data.
Significant	Identifies features which meet the NOAA significant contact height criteria set forth in the HSSD (see section 5.2.2 and 6.2.1), or some other priority condition determined by the field unit, and warrant further investigation and/or development. If applied to a Primary feature, the Significant flag will automatically be applied to all correlating Secondary features.
Tgt Exported	Denotes that an item was flagged Investigate and has been exported to MapInfo MIF/MID and HYPACK TGT format, typically for some subsequent investigation procedure. This flag will be set automatically when "Export Investigation Items" function in Pydro is performed. Once marked Tgt Exported, these items will not be re-exported unless the Tgt Exported flag is manually cleared prior to performing the export.
In Bathy	Forces a feature's least depth to be explicitly included in the PSS database of shoal-biased binned line (PVDL) data for plotting in Pydro, MapInfo (via Hydro_MI's "Draw PSS" function), or

	otherwise exported from Pydro. A sounding must first be classified as a bathymetric feature to be designated In Bathy. Once flagged In Bathy, that depth will take priority over other PVDL bathymetry data and other feature depths in the PSS during over-plot removal.
Designated	This flag is used to force a feature's least depth to be explicitly included in the two PSS bathymetry databases (as applicable) for display/analysis in Pydro (both over-plot removed Depths and ZSurfaces), plotting in MapInfo (via Hydro_MI's "Draw Pydro Data" Post Survey tool), or otherwise exported from Pydro: (i) HIPS BASE/Weighted Grid data and (ii) shoal-biased binned line (PVDL) data. During bathymetry layer over-plot removal (aka "excessing") in Pydro, feature depths may suppress other (deeper) feature depths; however, non-feature depths do not suppress feature depths, regardless of magnitude (i.e., all feature depths are regarded as being shoaler than all other depth nodes in the grid). In CARIS, the Designated flag should be used when a single least depth measurement is preferred over the weighted-mean depth calculation for BASE surface grid nodes. Designated soundings often equate to navigational significance and, hence, the desire for a symbolized feature to be rendered on the chart—and why HIPS Designated soundings are read into Pydro as candidate features (items from bathymetry). However, this is not always the case. For example, if the area of least depth has been adequately surveyed, yet contains a small number of soundings, the Designated flag should be used. Also, if a feature's least depth was determined by DLDG, the Designated flagging mechanism must be used to accurately represent the (single) measurement in the BASE surface. Designated soundings are applied to the BASE surface during the Finalize step in CARIS by checking the "Apply designated soundings" option.
Outstanding	Flagging a sounding Outstanding can only be accomplished in HIPS, but this action correlates to creating a bathymetry feature in Pydro. In other words, a sounding flagged Outstanding in the HDCS data will automatically be a bathymetry feature in the PSS. Likewise, creating a bathymetry feature in Pydro will write an Outstanding flag back to that sounding in the HDCS data.

Attributing and Flagging for Automated Feature Reports

Special Feature Types

The following attributes and flags shall be used to distinguish features for HCell compilation and the Feature Report.

Note: There are several logic paths for some of the items in Pydro

Special Feature Types:	CARIS & HYPACK	Pydro
DTONs	[prmsec = 1 Primary] + [sftype = 3 DTON]	Primary + Accepted (i.e., not flagged Rejected) + Chart + DTON
AWOIS	[prmsec = 1 Primary] + [sftype = 2 AWOIS]	• Report + Primary + [Keyword == "AWOIS"] • Report + Primary + Accepted + Non-DTONs + Secondary AWOIS
Maritime Boundary	[prmsec = 1 Primary] + [sftype = 2 Maritime Boundary]	• Report + Primary + [Keyword == "Maritime Boundary"] • Report + Primary + Accepted + Non-DTONs + Secondary Maritime Boundary

New and Charted Features

New & Charted Features:	CARIS & HYPACK	Pydro
New	[prmsec = 1 Primary] + [descrp = 1 New]	• Report + Primary + Accepted + Non-DTONs (with no Secondary from Chart GP or AWOIS) • Report + [Keyword==“DR_UnCharted”] + [Chart = New]
Updated	[prmsec = 1 Primary] + [descrp = 2 Updates]	• Report + Primary + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS) • Report + [Keyword==“DR_Charted”] + [Chart = Update]
Disproval	[prmsec = 1 Primary] + [descrp = 3 Delete]	• Report + Primary + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS) • Report + [Keyword==“DR_Charted”] + [Chart = Delete]
Retain	[prmsec = 1 Primary] + [descrp = 4 Retain]	• Report + Primary + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS) • Report + [Keyword==“DR_Charted”] + [Chart = Retain]
Not Addressed	[prmsec = 1 Primary] + [descrp = 5 Not Addressed]	• Report + Primary + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS) • Report + [Keyword==“DR_Charted”] + [Chart = Not Addr]

Customized Attribute Equivalencies
CARIS – HYPACK - Pydro

NOAA Required Attribution:

CARIS & HYPACK	Pydro	Comments
descrp	Chart -?	Description
prmsec	Status	Primary/Secondary status
remrks	Remarks	Remarks
recomd	Recommendations	*Only required for new and charted feature disprovals*
sftype	Keyword==ATON or AWOIS DToN Flag	Special Feature Type

NOAA Discretionary Attribution:

CARIS & HYPACK	Pydro	Comments
asgnmt	Keyword==Assigned	Assignment Flag
images	Images	Images
keywrd	Keyword	Customized keyword
acqsts	Investigate & Resolved Flags	Acquisition status
invreq	Remarks	Investigation requirements
prkyid	NA – CARIS and HYPACK only	Primary key ID – supports manual correlation in CARIS and HYPACK
userid	DispName	Unique ID

Standard Shorthand for Features

Notes made in Remarks or Recommendations fields should be concise and use approved shorthand:

att	attached	mllw	mean lower low water
bdk	bedrock	mbes	multibeam echosounder
bch	beach	mnt	maintained
bkwr	breakwater	N	north
blldrs	boulders	nain	not addressed inshore of NALL
brg	bearing	nall	navigable area limit line
ch	channel	ntd	noted
chd	charted	ofsh	offshore
cir	circle	ort	oriented
conn	connected	par	parallel
cov	covers	pos	position
c/u	covers/ uncovers	pt	point
dbn	daybeacon	pvt	private
dia	diameter	rk	rock
dis	disproval	rng	range
DP	detached position	shl	shoal
dup	duplicate	sig	significant
E	east	sl	shoreline
ext	extent	sndg	sounding
ftr	features	S	south
fl	flashing	subm	submerged
flt	floating	swm	seaward most
fm	fathoms	vbes	vertical beam echo sounder
ft	feet	vfd	verified
GC	Geographic Cell	W	west
ht	height	wtr	water
hp	high point		
hw	high water		
inshr	inshore		
invst	investigation		
klp	kelp		
ldg	ledge		
ldr	lidar		
lmt	limit		
lt	light		
ltd	lighted		
lw	low water		
m	meter		
mhw	mean high water		

Appendix 5

Data Management and Survey Deliverables

CONTENTS

Digital Data Submission Checklist

OPR-A###-FA-##

HXXXXX Survey X

CARIS

Background Files

- ______ Any background files to be submitted with the survey

Fieldsheets

- ______ HXXXXX (Non-Finalized BASE Surfaces)
  - ______ HXXXXX_2m_0to40 Naming convention: HXXXXX_Resolution(m)_DepthRange
  - ______ HXXXXX_5m_30to70
  - ______ HXXXXX_10m_50to120
  - ______ HXXXXX_20m_100to200
  - ______ HXXXXX_35m_180to350
- ______ HXXXXX_Final_Combined (Finalized & Combined BASE Surface)

HDCS_Data

- ______ HXXXXX (processed CARIS HDCS data)
- ______ Critical Soundings
- ______ VesselConfig (only vessels that apply to this survey)
  - ______ DeviceModel.xml (DeviceModel used for processing this survey)

Notebook Files

- ______ HXXXXX_Original_Composite_Source.hob
- ______ HXXXXX_Composite_Source.hob OR HXXXXX_Updates_Ntbk.hob
- ______ HXXXXX_Updates_Pydro.hob
- ______ HXXXXX_Disprovals.hob

Preprocess

- ______ ISIS (raw XTF data and True Heave from ISIS)
- ______ SVP_raw (raw SV data from Velocwin)
- ______ Trimble (raw data from TerraSync & exported SHP files from GPS PathFinder)

SVP (processed CARIS SVP data files separated by vessel)

- ______ 1010
- ______ 1018
- ______ S220

Tide

- ______ Observed, Verified or Smooth .tid & .zdf (only tide files applied to data at time of submission)

* No Sessions submitted at this time

DESCRIPTIVE REPORT

Report Body

- ______ HXXXXX_Descriptive_Report.doc
- ______ HXXXXX_Title_Sheet.pdf
- ______ HXXXXX_Cover_Sheet.pdf
- ______ Digitally Signed Approval Memo

Appendices

I. DTON Report(s)

- ______ HXXXXX_DTON.xml (XML of DTONs exported from Pydro)
- ______ HXXXXX_DTON_Report.pdf (report produced in Pydro)
- ______ HXXXXX_DTON_email.txt (copy of submission email)
- ______ other email correspondence related to DTONs including MCD confirmation

II. Survey Feature Report

_______ HXXXXX_Survey_Feature_Report.pdf (report produced in Pydro)

III. Final Progress Sketch & Survey Outline

_______ HXXXXX_Survey_Outline.tab & final Progress Sketch files

IV. Tides & Water Levels

_______ Official smooth tide note issued by CO-OPS to identify files used for final correctors

Request for Tides

_______ HXXXXX.pdf (Smooth Tides Request & Abstract Times of Hydro)

_______ HXXXXX.mif/mid files

V. Supplemental Survey Records & Correspondence

_______ HXXXXX_Correspondence.xxx (digital copies of emails, request & correspondence)

Separates

I. Logs

Acquisition & Processing

_______ HXXXXX_1010_8101_Log.xls

_______ HXXXXX_1010_8101_Log.xls

_______ HXXXXX_S220_8111_Log.xls

_______ HXXXXX_S220_8160_Log.xls

Detached Positions

_______ HXXXXX_Pydro_Feature_Log.xls

_______ HXXXXX_DPForms.pdf (Scanned DP forms)

_______ HXXXXX_Boat_Sheets.pdf (Scanned boat sheets)

II. Sound Speed Data

Not Applicable, submitted by Project with the DAPR

III. Hydrographic Survey Letter Instructions

_______ Letter Instructions, changes and amendments for the project

IV. Checkpoint Summary & Crossline Comparisons

_______ Checkpoint Summary & Crossline Comparisons

Public Relations and Constituent Products

_______ Include all products that were provided to constituents or used for PR

PSS

(Pydro Preliminary Smooth Sheet)

_______ HXXXXX.PSS

_______ Photos (Non-SSS contact images associated with Pydro features, named w/unique identifier)

HXXXXX Contents

_______ Survey data included in transmittal list text file

_______________________ size

_______________________ number of files

_______________________ number of folders

Command prompt H: (to go to drive) cd (can use rt click paste to put in path to folder)

Hydrographic Survey Quality Control Checklist

Survey: HXXXXX **Project:** OPR-XXXX-FA **Survey PIC:** ____________

SURVEY PLANNING

Completed: ______ INITIAL ______ DATE

________ Read and Understand the project Instructions
- ______ Letter Instructions
- ______ Standing Instructions

________ Start filling in Survey Log
- ______ pertinent Chart scales listed

________ Shoreline Prep
- ______ Shoreline files prepped
- ______ Boat sheets produced
- ______ TIF/TFWs opened and checked in TerraSync
- ______ Initial TIF/TFWs produced for MBES launches in Isis

________ Cross Lines
- ______ Plan to run crosslines early, prior to MS if possible
- ______ Plan to obtain 10%
- ______ Atleast 5% collected

________ Multibeam Polygons produced and updated
- ______ DO NOT send multibeam boats inshore of the eight meter curve until shoreline has been run in area
- ______ Initially create SHIP & LAUNCH polygons only - Launch polygons can be driven by any Cox'n
- ______ NEAR_SHORE & HIGH_WATER_ONLY polygons not created until shoreline has been run in area
  - ______ Discuss NEAR_SHORE & HIGH_WATER_ONLY areas with FOO/CST - run by experienced Cox'ns only
- ______ Polygons converted to shp format and put in R/Transfer and on Launch hard drive

________ Bottom Samples Prepped
- ______ Bottom Sample chartlet/boat sheet produced
- ______ Create a tif/tfw of your bottom sample sites
- ______ TIF/TFWs opened and checked in TerraSync

DAILY CHECKS

Completed: ______ INITIAL ______ DATE

________ Quality Control of Survey Data
- ______ Review BASE surfaces
- ______ Review data in subset mode for SV error, tide problems, holidays & noise
- ______ Check coverage and update polygons
- ______ Check for immediate DTONs and notify FOO
  - ______ Immediate DTONs submitted

________ Review Acquisition and Processing logs
- ______ Check for issues/problem data in both Acquisition and Processing sections
- ______ Make sure the SV application method is documented (e.g. NIDWT-4hrs)
- ______ Note if True Heave could not be applied & document in DR

________ Track issues in HXXXXX_Survey_Log.doc
- ______ Note which vessels were used for the day (especially useful for shoreline boats)
- ______ Document special circumstances/problems, HVF changes & deviations from DAPR
- ______ Issues explained in DR

FIELD PROCESSING

Completed: ______ INITIAL ______ DATE

________ Pydro Processing
- ______ All DPs/GPs & Bottom Samples imported
- ______ Features reviewed, flagged, S57 attributed and CartoAction selected
- ______ Remarks/Recommendations completed

_____ Pictures labeled correctly, in one folder, & inserted in PSS
_____ AWOIS investigations completed
    _____ .mbd file inserted in Pydro
    _____ Database updated in AWOIS editor, with investigation methods and remarks
_____ Tide and SVP correctors applied where necessary
_____ HXXXXX_Pydro_Feature_Log completed
_____ Feature .xml's exported using Pydro Tree Templates

_______ Notebook Processing
_____ All Pydro features imported
_____ Features reviewed with DP forms and boat sheet
_____ Address all data including CFF, Chart, Lidar, and new items
    _____ All remarks fields completed or state "Unable to Verify"
    _____ Unverified items flagged with Marker Text
    _____ Photos, not associated with a Pydro feature, added to features in Ntbk in a marker note
        _______ Notebook Photos are stored in PSS\Photos\Notebook Photos
_______ Verify Sound Velocity Files
_____ Compare SVP files listed in digital acquisition logs with files on I: drive – all should match
_____ Review cast profiles in HIPS SVP Editor
_____ Display SV cast positions in CARIS to check for gross error
_____ Check file management on H: and I: drives
_____ Query data to make sure only master concatenated files (*HXXXXX_VSSL.svp*) were applied
    _____ If *HXXXXX_VSSL.svp* is not applied to lines, then discussed in DR
    _____ SV acquisition/processing deviations from the DAPR are noted in the DR.

_______ Updated Shoreline TIF/TFWs created and sent out to field before any near shore MBES run

_______ Examine Range Displayed CUBE surfaces (make sure that CUBE surfaces have Depth Ranges in name)

_______ Coast Pilot review & write up with edits completed

POST ACQUISITION **Completed:** _______ INITIAL _______ DATE

_______ Review of CARIS Data
_____ Re-insert all HDCS lines (not DPs) into HXXXXX_QC session
_____ Review data using CARIS Subset Editor (include looking at rejected and BASE child layers)
    _____ Subset tiles created for review process
    _____ Data checked for systematic errors (Std deviation child layer especially useful)
    _____ Flyers cleaned out, where it affects appropriate surface for that depth
    _____ Contours & Soundings generated from finalized/compiled surface (CARIS FS Editor)
_____ Review all examined soundings (to designate, mark outstanding, or reaccept)
_____ Designate soundings in areas where surface does not accurately represent the bottom
    _____ # of Designated Soundings
_____ Data issues discussed in DR if present

_______ Smooth Tides Request (*.mif/mid and times of Hydro)
_____ All data inserted in Pydro for correct Times of Hydrography
_____ Request with letter, times, & mif/mid generated and saved in Appendix III
_____ E-mail CST & FOO when complete

_______ Survey Outline
_____ Produced & saved in Appendix III
_____ E-mail CST & FOO when complete

_______ DTONs (Dangers to Navigation)
_____ Select DTONs
    _____ soundings marked outstanding in CARIS
    _____ inserted in Pydro as CARIS Line Feature
_____ Notify FOO that they are ready for review
_____ DTONs chosen by CO should be marked Designated in Pydro or CARIS
_____ Use the Pydro Report function to generate a DTON Report
_____ E-mail CST, FOO & CO when selection and report are complete

______ Submittal e-mail/DTON Report saved in PSS folder

________ Additional (Observed, Verified or Smooth) Tides Applied
______ Tide file reviewed & checked for gaps/flyers (txt in Notepad, .tid in Caris Tide Editor)
______ Apply zoned file to all HDCS lines
______ Apply zoned file to all DPs
______ Data remerged in CARIS after tides have been re-applied.
______ Recompute BASE surfaces

________ Complete H#####_Data_Log (file is in Separates\Logs)
______ MBES MS tab complete, query Main Scheme lines only
______ Count data files on H: and I: drives
______ Number of raw files matches number of HDCS lines, and matches total # of survey lines
______ Compare queries to daily acquisition logs to check for discrepancies
______ Tide correctors applied are correct and most current (observed, verified or smooth)
______ Master SV files applied for all vessels (or as noted in DR)
______ Vessel speeds meet object detection requirements for relevant depths
______ MBES XL tab complete, query Crosslines only
______ MBES DEV tab complete, query Development lines only (generally lines run over AWOIS items)
______ Features Query completed in H####_Data_Log
______ Compare fields of matching colors
______ Statistics tab reviewed and box copied to DR
______ Problems/discrepancies investigated

________ Pydro Review
______ All features resolved
______ DP forms match features in PSS
______ Scanned into a single .pdf and saved in DP Log folder
______ Use DP editor to ensure correct vessels were selected for all data
______ Apply necessary correctors (tides) to DPs and merge data
______ DPd for height items - additional processing complete
______ copy attributes from Pydro to Ntbk feature (watlev etc)
______ change UWTROC in Pydro to $CSYMB
______ if smooth tides delivered, copy smooth tide height of feature to Ntbk, update DR
______ Remarks/Recommendations completed
______ Disprovals marked Report, contain search methods in Remarks & have a recommendation
______ Chart GPs produced if necessary
______ Changes to MHW (including islets) marked Report
______ include description paragraph in Remarks and have a recommendations
______ AWOIS items finalized
______ Features Report produced and saved in Appendix I

________ Notebook Review
______ Features compared to Pydro session
______ Remarks reviewed for consistancy & completeness (All features must have a remark!)
______ S57 attribution correct and complete

________ Descriptive Report
______ Digital images of limits and junctions produced and inserted
______ Fill in Statistics in Data_Log & add the box to DR using paste special as picture
______ Dates of survey match- DR, Cover Sht, Title Sht,Sm Tide Req, Raw Isis & Trimble folders
______ Check that the General & Sub-Locality for survey in DR, Cover Sht, & Title Sht matches LIs
______ Add LI date signed added to DR, if LI changes affect your survey add verbage to that affect
______ Cross-line comparisons completed and documented
______ Required quantity of XLs met. If not, addressed in DR.
______ Junction comparisons completed and documented
______ Prior surveys were reviewed because of special issues
______ Issues explained in the DR
______ Chart comparisons completed and documented
______ Chart edition & date corrected through included in DR
______ Notice to Mariners checked for recent updates
______ Special circumstances, problems, HVF changes, deviations from DAPR documented

______ Shoreline processes described
______ Separates reviewed & complete
______ Acquisition logs checked
______ ________ True Heave applied and how SV applied noted (nearest in time etc.)
______ Coverage requirements were met (use finalized surfaces to assess coverage)
______ If not, addressed in DR.
______ Run the interpolation/triagulation to assess holidays
______ For holidays larger than 3 nodes across
________ corresponding MBES backscatter sidescan was examined
________ were any navigationally significant items found in backscatter?
________ Discuss in DR, if necessary
______ Accuracy requirements were met (use IHO error calculator)
______ If not, addressed in DR

SUBMISSION **Completed:** ______ INITIAL ______ DATE

________ Data Checked & Ready for Review
______ Any HVF changes or alterations are discussed in DR
______ H#####_QC session ready
______ If multiple fieldsheets are necessary, naming includes resolution & geographic identifier
______ Surfaces include depth threshold ranges and resolutions in name
________ cov or bot_dep in name, if bottom depiction srfcs used in addition to coverage srfcs
______ Finalize surfaces with depth thresholds applied; to produce critical soundings
________ Use finalized surfaces to assess that coverage requirements were met
________ Adjust overlap if necessary, there should be no gaps between surfaces
______ Produce a combined surface from finalized surfaces
________ produce soundings & contours from combined surface
______ Open and save to session the best chart(s) for the survey area
______ Make combined surface transparent, so that chart shows through
______ PSS data is not Stale or Outdated
______ Shoreline session contains all files named properly & located in Notebook Files folder on I: drive
______ Create & Examine Fledermaus session from compiled surface, save to Survey Files/Fledermaus

________ Descriptive Report Components
______ Approval Memo, Cover & Title sheets copied from templates, completed and saved in DR folder
______ Appendices completed as necessary
______ Separates completed as necessary
______ Three-hole punch hard copies of DP forms & boat sheets and put them in a folder with a label

________ File Management
______ File management SOP consulted
______ Fieldsheet folder contains only deliverable fieldsheets, all others removed
______ All files accounted for and in correct location
______ Content of all submission folders (CARIS, DR, Field Products, & PSS folders) checked
Complete, suitable, and non deliverable items removed

________ Notification e-mail to CST & FOO that survey is ready for review

________ All data and DR submitted for Review and Approval

POST-APPROVAL **Completed:** ______ INITIAL ______ DATE

________ Digitally sign approval memo and put in Descriptive_Report\Report_Body\Approval_Sheet folder

Hydrographic Survey Review Checklists

Survey: ________________ Project: ________________________

QC REVIEW QC Reviewer: ________________ **Completed:** ______ ______
INITIAL DATE

Bold underlines require date and initials when item is completed.

________ **1. Survey Data and Documentation Familiarization**

QC Check reviewed

________ Quality Control Checklist done by sheet manager is complete and reviewed

Descriptive Report reviewed

________ Check that the cover sheet, title sheet and the DR information correspond with Letter Instructions (eg. Locality, Registry #, etc.)
________ Base Surface and Field sheet Table
________ Date for Letter Instructions in DR is correct
________ Review survey feature report
________ Statistics
________ Review Appendices
________ Review Separates

Logs reviewed

________ Digital Acquisition & Processing Logs
________ Pydro Feature Log
________ Data Log
 ________ Feature Query reviewed, appropriate features were exported to Notebook
 ________ Check Statistics & Dates of Survey
  ________ DR, Cover Sht, Title Sht & Sm Tide Req should match raw (PREPROCESS) data, including Trimble
________ Survey Log

________ **2. Data Quality**

MBES - CARIS HIPS & SIPS

________ HDCS data, fieldsheets, and base surfaces open in CARIS and are not outdated
 ________ BASE Surfaces contain least Depth, Uncertainty, and Standard Deviation attributes

________ Proper corrector files applied to data
 ________ Tide
 ________ SVP

________ Sound Velocity
 ________ Evaluate profiles
 ________ View positions

________ Tide files: If smooth tides have been applied:
 ________ Evaluate tide file in CARIS tide editor (no gaps or spikes in data)

Features

PYDRO

 ________ Verify PYDRO information matches DP form
 ________ Remarks/Recommendations are appropriate and not confusing
 ________ Verify S-57 attribution
 ________ Verify PYDRO flags
  ________ All features are resolved
 ________ Verify all AWOIS items have been addressed

CARIS Notebook

 ________ Verify all features have been addressed
 ________ Verify S-57attribution
 ________ Review features with BASE Surface

CARIS HIPS

 ________ Verify DPNE lines have the correct Tide file applied and are Merged
 ________ Verify DPES lines have SV applied, the correct Tide file applied and are Merged

DTONs

________ Verify DTONs
________ DTON Report in DR matches DTONs in PYDRO

________ **3. Data Accuracy**

Systematic Errors

________ BASE Surfaces reviewed for sound velocity, tide, roll bias or timing bias, etc.
________ Have errors been documented in the DR

Coverage and Object Detection

________ Coverage and accuracy requirements were met

BASE Surfaces

________ Verify CARIS BASE Surfaces are threshold by depth and are of appropriate resolution
________ Verify the Finalized/Combined CARIS BASE Surface
________ Verify all significant shoals, DTONs and designated soundings have been examined

Designated Soundings

________ Review all to ensure appropriate sounding selected (eg. not outerbeam or noise)

Subset Review

________ Review 10% of survey in subset mode (include looking at rejected data)

Quality Control

________ Required percentage of crosslines have been conducted
________ Crosslines represent a sample of the entire survey area
________ Examine 10% of crossline junctions
________ Areas that exceed allowable errors discussed in DR
________ Contours & Depths checked
________ Chart comparisons reviewed
  ________ Ensure chart edition and date corrected through included in DR

FINAL REVIEW Final reviewer: ____________________ **Completed:** ________ ________
INITIAL DATE

________ Final Review completed
  ________ Data and DR are approved
    ________ Descriptive Report & Appendices reviewed
      ________ Survey Feature Report reviewed
    ________ Pydro/Notebook Sessions reviewed
    ________ Data reviewed in Fledermaus

CO REVIEW **Completed:** ________ ________
INITIAL DATE

________ Data review
________ DR review
________ Signed Approval Memo

FileVerifier++ SOP Version 1.0
Grant Froelich
Pacific Hydrographic Branch

Contents:

1| Background

A checksum or hash sum is a fixed-size datum computed from an arbitrary block of digital data for the purpose of detecting accidental errors that may have been introduced during its transmission or storage. The integrity of the data can be checked at any later time by recomputing the checksum and comparing it with the stored one.

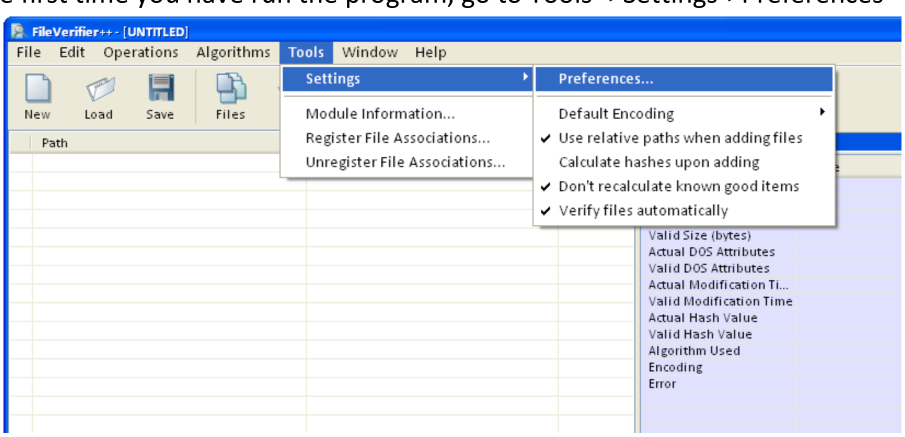
NOAA field units shall create MD5 checksums for all digital data submitted to the processing branches. This SOP outlines the procedure for creating, verifying, and reporting the results of the verification process using the program FileVerifier++.

This SOP is intended to be used with FileVerifier++ version 0.6.3.5830W or later.

2| Creation of Checksums

To create checksums, first copy all the digital data to be submitted to the processing branch to the submission drive. Once all the data has been copied, create a MD5 checksum file with Windows Line Endings, Unix Path Separator Characters and a custom MD5 file comment using the following procedure:

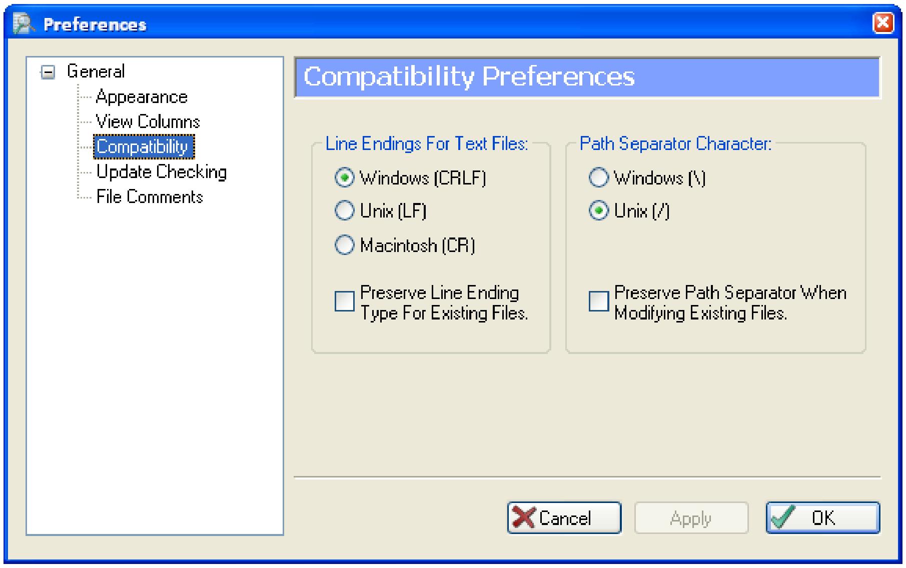
1. Open FileVerifier++ by opening the fv.exe file from Windows Explorer
2. If this is the first time you have run the program, go to Tools ->Settings->Preferences



a. Under General ->Compatibility change

   i. Line Endings for Text Files to Windows (CRLF)

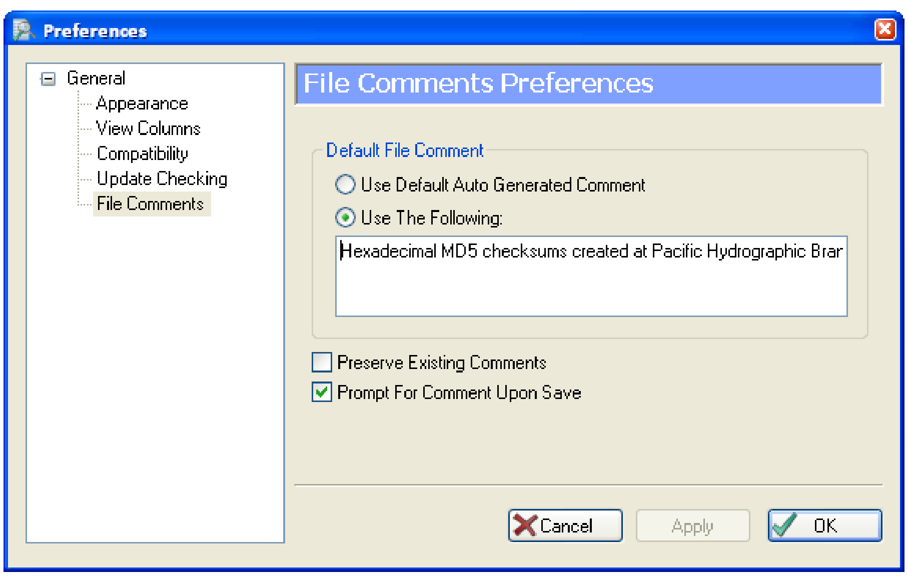
   ii. Path Separator Character to Unix (/)



b. Under General->File Comments change

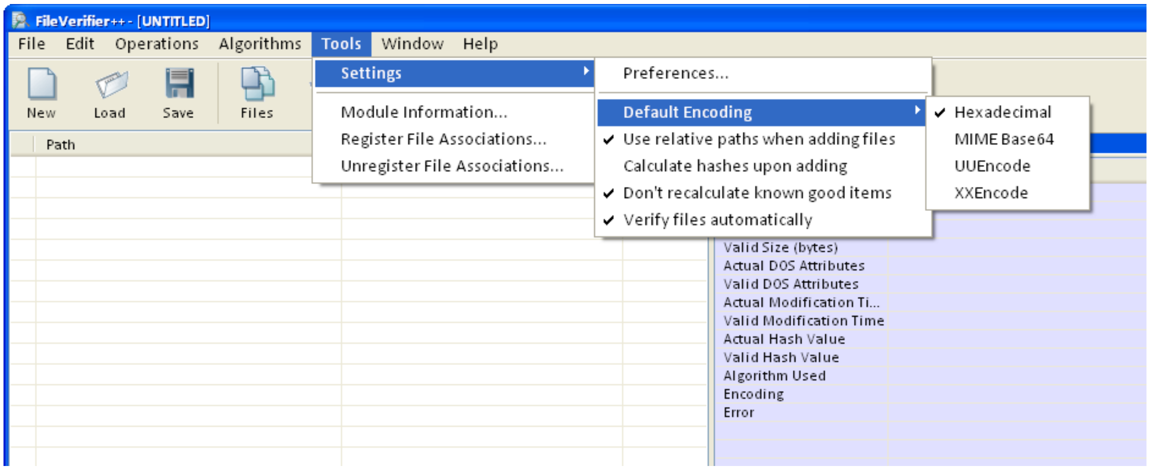
   i. Default File Comment to "Hexadecimal MD5 checksums created at *{insert field unit name here}* on YYYY-MM-DD"

   ii. Check Prompt For Comment Upon Save

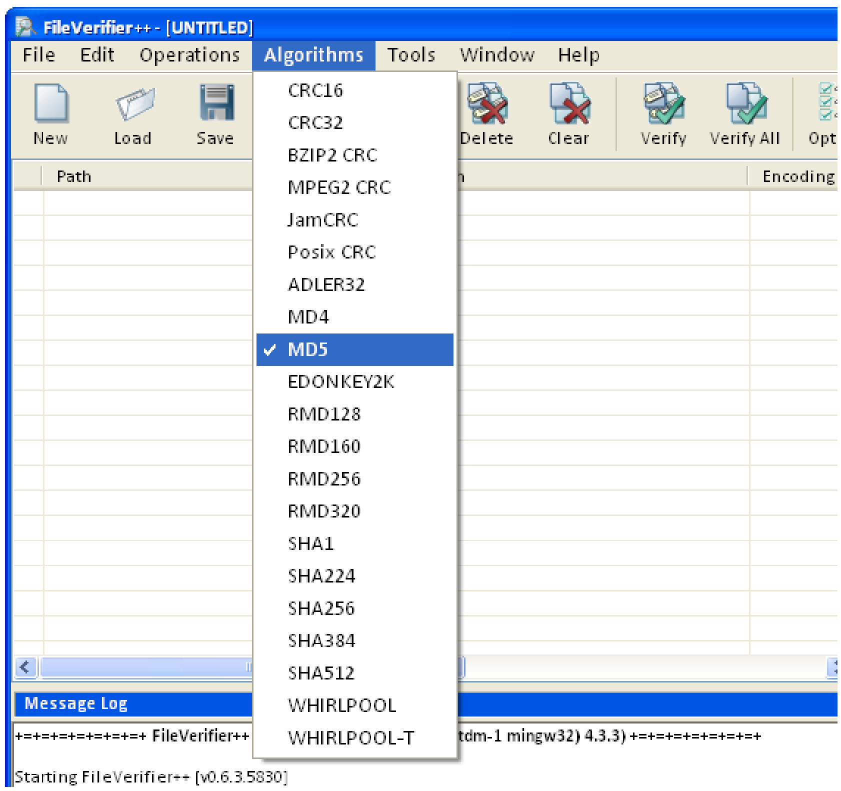


c. Under Tools->Settings->Default Encoding-> Select "Hexadecimal"

d. Under Tools->Settings->Select "Use relative paths when adding files"

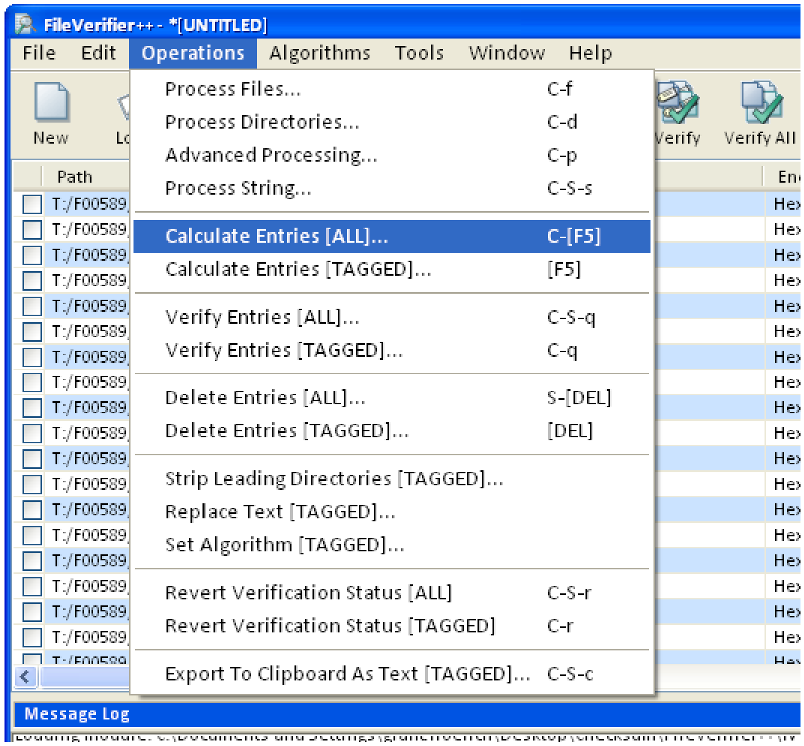


e. Under Algorithms-> Select “MD5”

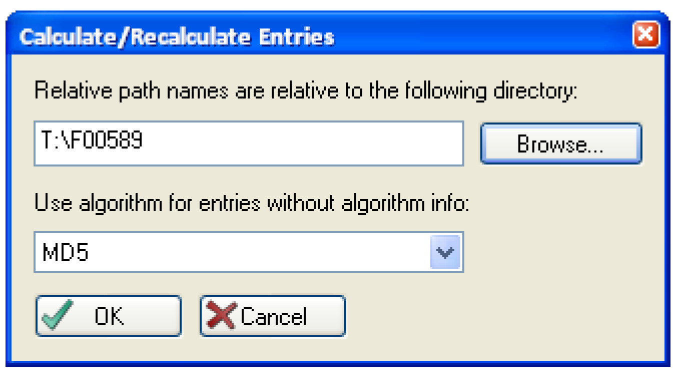


3. Once you have all your settings correct, you can add the files to be checksumed
    a. Select the “Dirs” button and browse to the H12345 folder on the submission drive

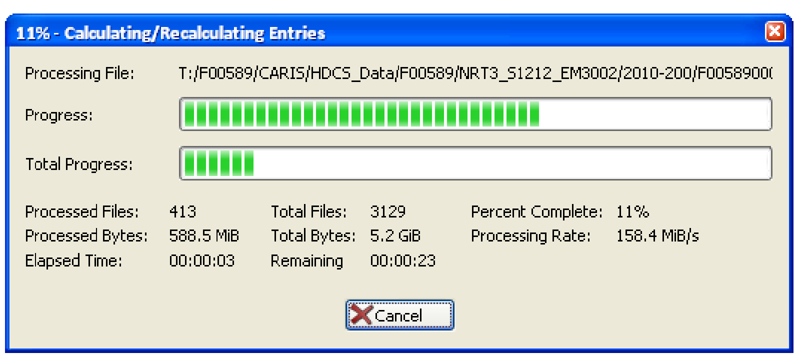
    b. Under Operations-> Select “Calculate Entries [ALL]…”



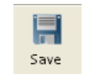
c. Enter the base path of the submission folder (ex. T:\H12345) in the Relative path names entry dialog and click okay



d. The process will begin and you will get a status bar telling you how far along you are

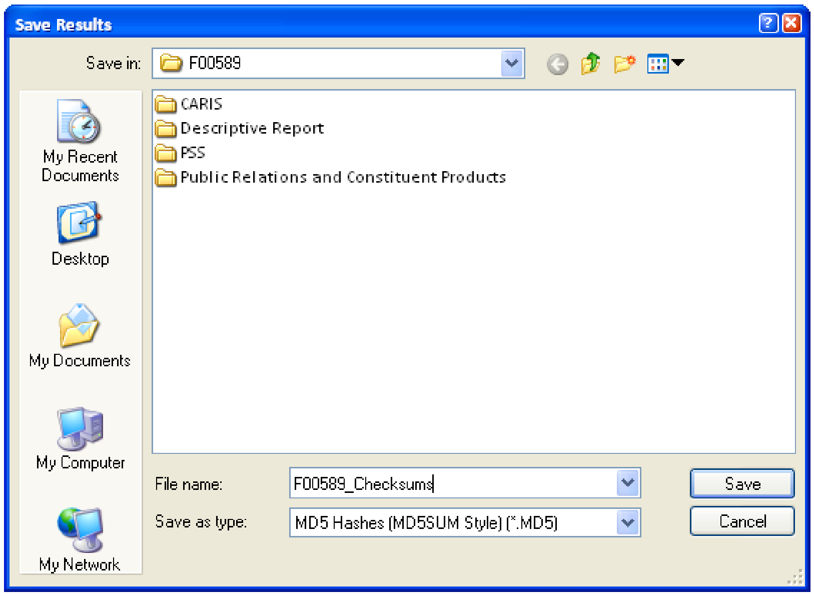


e. When it is finished, click on the "Save" button

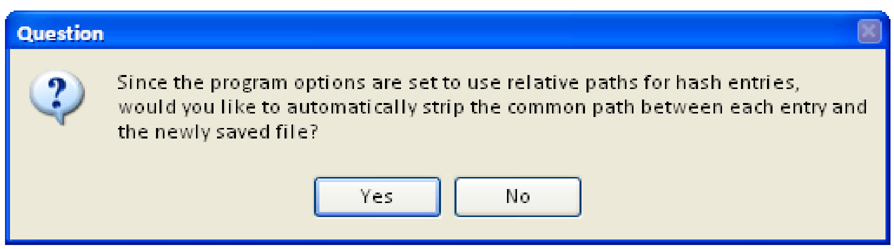


i. Give the checksum file a name using the naming convention HXXXXX_Checksums.MD5 and place it in the base folder (ex T:\H12345)

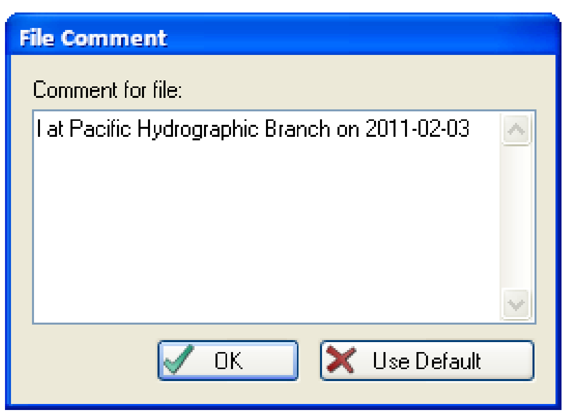
ii. Save as "MD5 Hashes (MD5SUM Style) (*.MD5)"



iii. Answer "Yes" to the question about relative path stripping



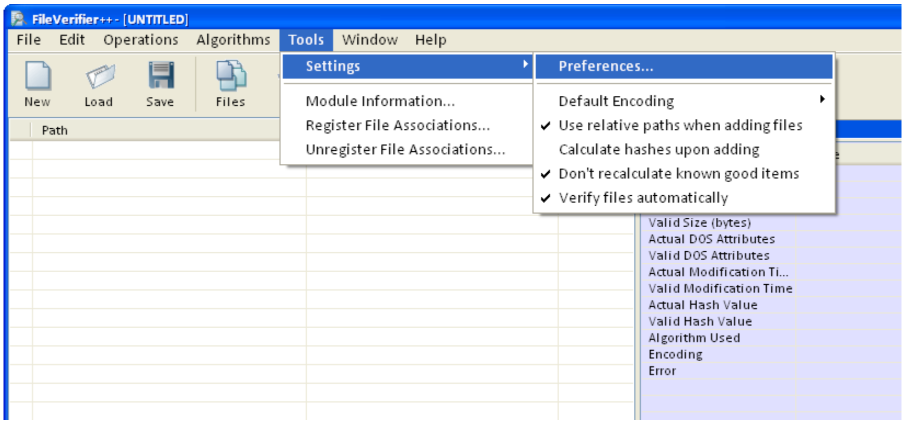
iv. Modify the date in the comments to the current date



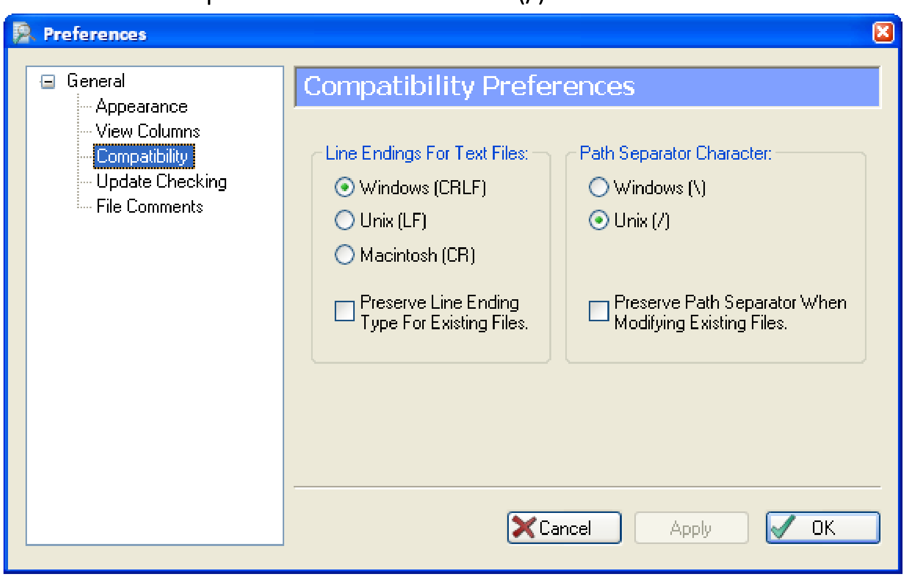
3| Verification of Checksums

To verify checksums, first copy all the submitted digital data to the network drive where it will be stored. Then verify that the data has not been altered by loading the checksum file and comparing the checksums of the files as they currently exists to how they existed on the ship using the following procedure:

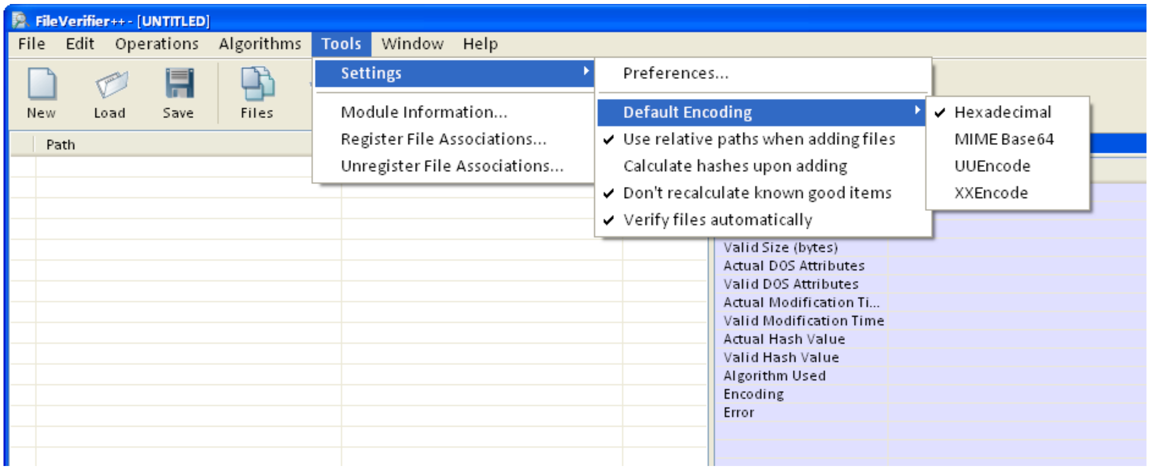
1. Open FileVerifier++ by opening the fv.exe file from Windows Explorer
2. If this is the first time you have run the program, go to Tools ->Settings->Preferences



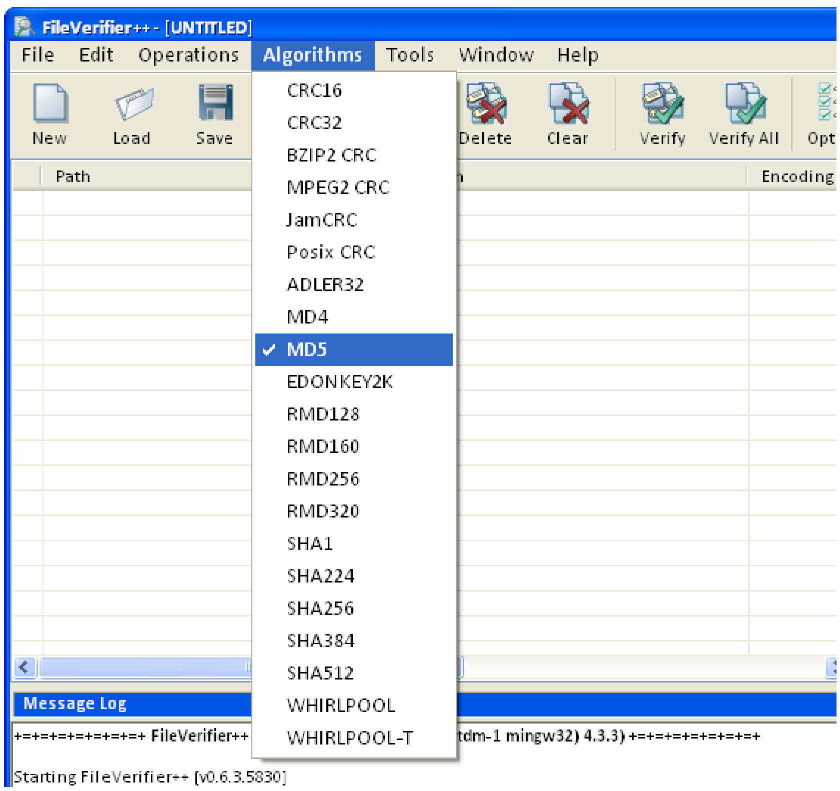
   a. Under General ->Compatibility change
      i. Line Endings for Text Files to Windows (CRLF)
      ii. Path Separator Character to Unix (/)



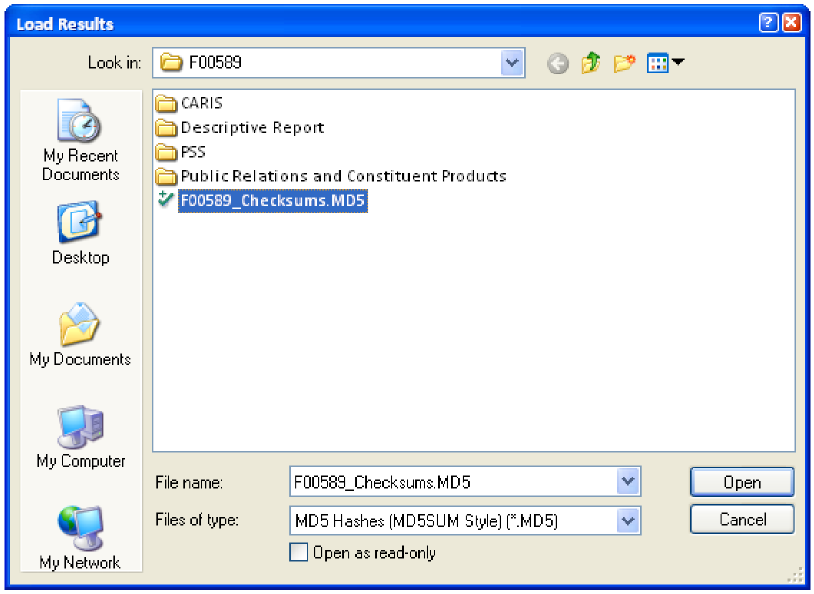
   b. Under Tools->Settings->Default Encoding-> Select “Hexadecimal”



c. Under Algorithms-> Select "MD5"

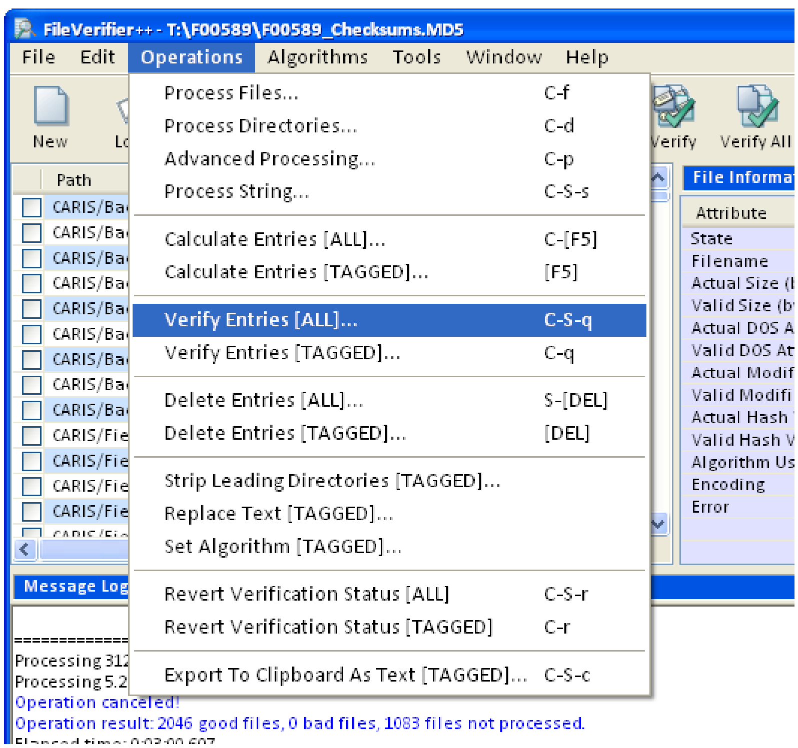


3. Open the MD5 Checksum file by clicking on the "Load" button 

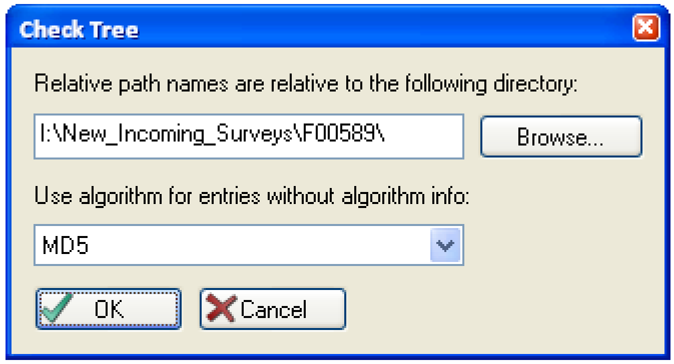


a. If you have" Verify files automatically" selected in the Tools->Settings menu, the comparison will begin automatically.

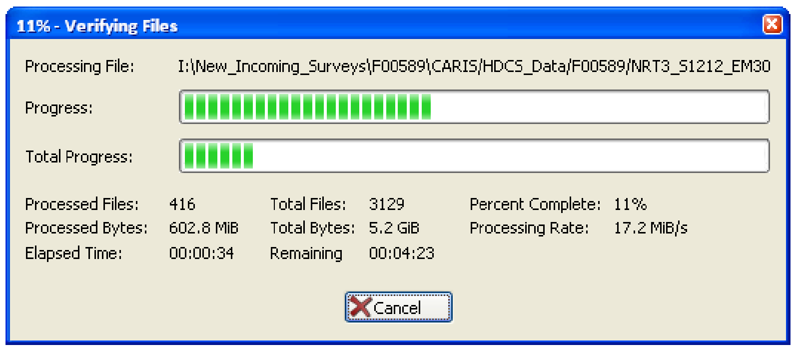
b. If not, under Operations-> Select "Verify Entries [ALL]…"



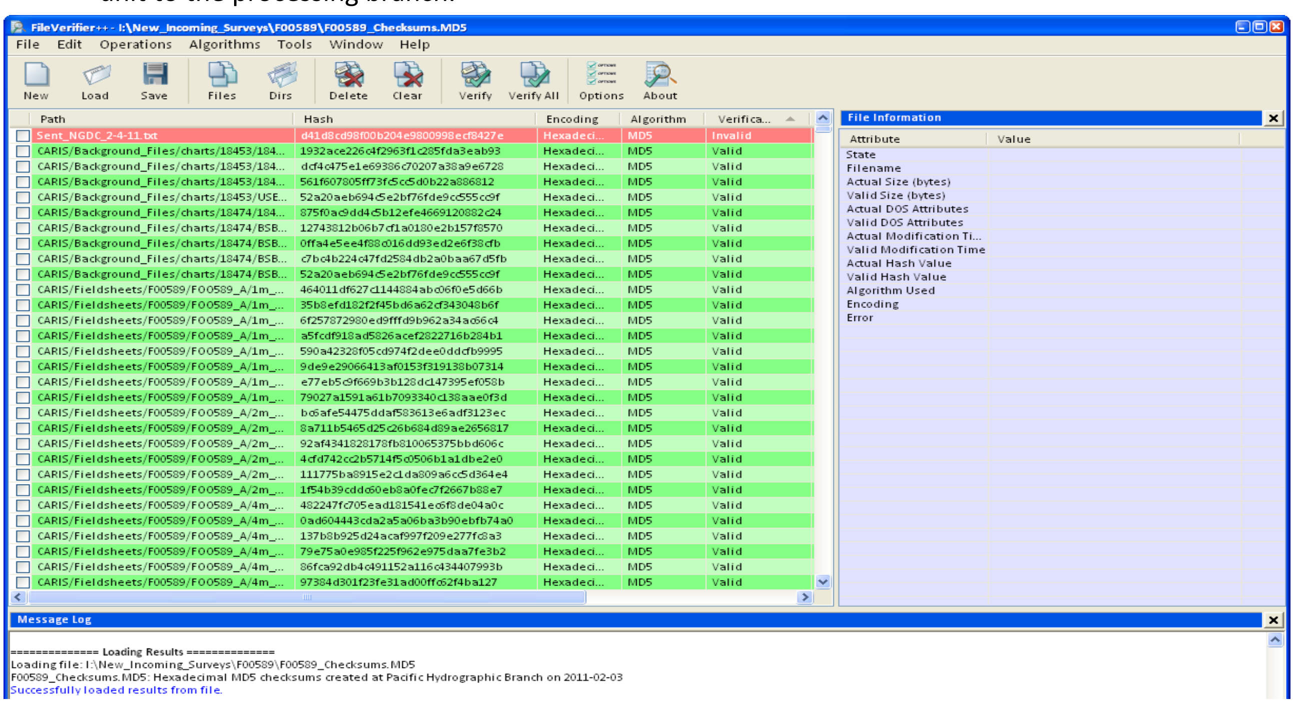
c. The Relative path names entry dialog should already be pointing to the current root folder but if not, point to it now and click OK.



d. The process will begin and you will get a status bar telling you how far along you are



4. When the verification process is complete, sort the columns by "Verification". If any files have been altered or deleted between the field unit and the processing branch network they will show up as Invalid and be colored red. These files will need to be re-transmitted from the field unit to the processing branch.

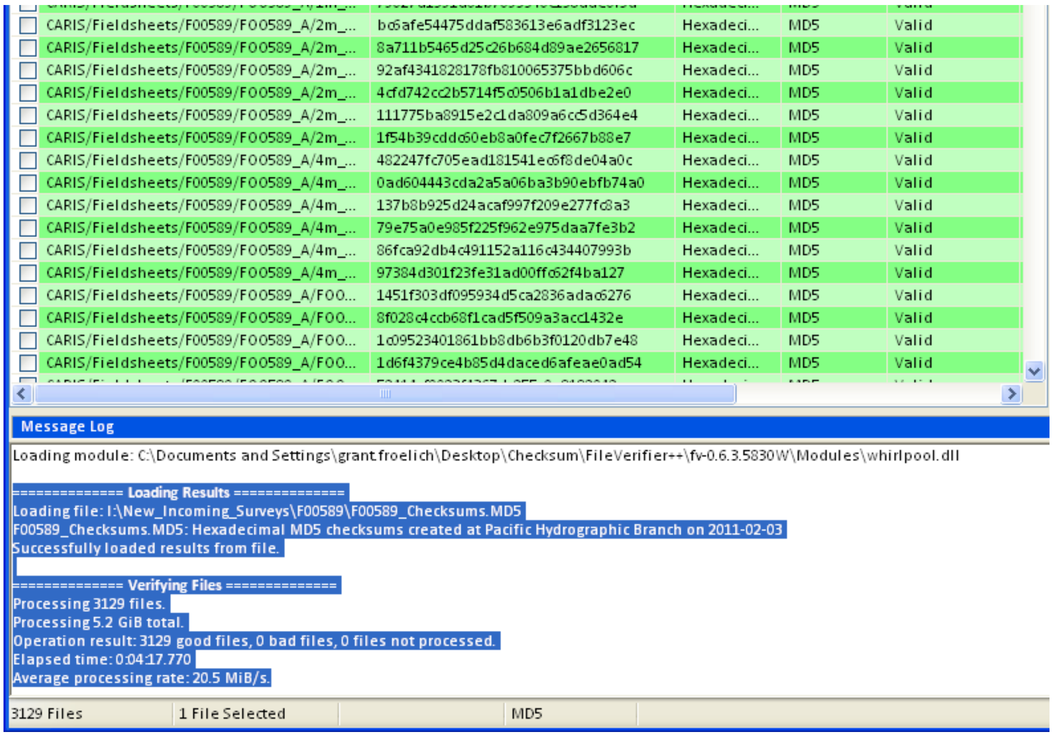


5. If all files have valid checksums then a report shall be created noting this

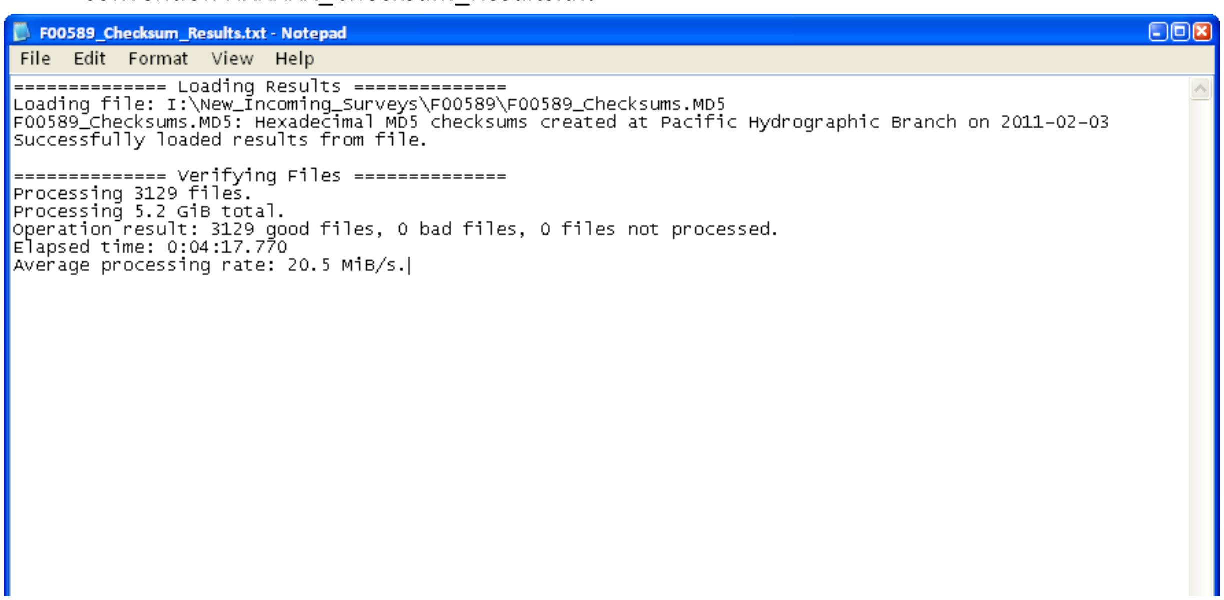
4| Reporting Results

If you have successfully verified all files in the submission, report the results of the verification using the following procedure:

1. Select the Loading Results and Verifying Files text from the Message Log window



2. Copy the text to a new text file in the submission root folder which is named with the naming convention HXXXXX_Checksum_Results.txt



U.S. Department of Commerce
Form Revised 26 February 2010

National Oceanic and Atmospheric Administration

FIXED AIDS FOR USCG I-ATONIS

US Coast Guard District	State	Locality	Reporting Unit

OPR Project No.	Survey Number	Datum	Make & Model of Positioning Equipment	From Date	To Date

LIGHT LIST NUMBER	AID NAME	LATITUDE dd-mm-ss.sssN	LONGITUDE ddd-mm-ss.sssW	HORIZONTAL ACCURACY @ 95% CONFIDENCE LEVEL	HORIZONTAL POSITION METHOD* *(see footer)*	LARGEST SCALE CHART AFFECTED	I-ATONIS Date
12345	Example Purpose Only GPS	48-50-30.332	065-55-45.789	0.8 meter	Post Process GPS	17345	
New	Example Purpose Only Photo	48-50-30.333	065-55-45.790	2.5 meter	Photogrammetry	17345	

Additional Comments: *(This space is for additional narrative on problematic ATONs. Examples are: ATON is not serving its intended purpose, difficulties encountered while positioning, or horizontal accuracy issues. For ATONs positioned using Detached Positioning state whether or not the new position is better than what is currently charted. Include light list number. This form* ***DOES NOT*** *replace requirements for DTON reports.)*

* Horizontal Position Method: e.g. DGPS only, Post Processed GPS, Detached Position, photogrammetric